NEW YORK FISH AND GAME JOURNAL

VOLUME 25 JANUARY, 1978 NUMBER 1

MORTALITY AMONG WHITE-TAILED DEER FAWNS ON THE SENECA ARMY DEPOT[1]

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ABSTRACT

During the winter and spring of 1972, 46 female while-tailed deer of two pelage colors (normal brown, or white—not albino) and three age groups (1, 2 and 3 or more years) were captured by remote injection of succinylcholine chloride on the Seneca Army Depot near Romulus (N.Y.). Each was marked with an identifying neck band and sheep bell. Observations of the marked does and their subsequent families were generally made within a few days after parturition. Significantly fewer fawns were observed with 2-year-old and 3-or-more-year-old does than had been expected. Two weeks after parturition, mortality among the fawns of these does amounted to 22 and 19 per cent, respectively. An insufficient sample of yearling does prohibited significant comparisons with respect to the survival of their fawns. Fawns reaching the age of 2 weeks appeared quite secure, only 2 per cent being lost during the following 2-month period. Fawn : doe rations obtained after September 1 were nearly identical for the families of marked and unmarked does, suggesting that marking had a negligible effect on fawn survival. No significant difference in rearing success was observed between the fawns of 25 brown does and those of 21 white does.

Fawn mortality may be an important limiting factor in populations of the white-tailed deer (*Odocoileus virginianus*) as reported by Cook et al. (1971). The degree of this loss may be dependent upon predator and parasite populations (Cook et al., 1971; Knowlton, 1964; Hair, 1968) and the degree of nutritional deficiency encountered by the pregnant and nursing doe (Verme, 1962; Murphy and Coates, 1966). Since no two populations or habitats are identical, fawn mortality may vary consider-

[1]Derived from an M.S. thesis submitted to the faculty of the State University College of Environmental Science and Forestry at Syracuse. This study was made possible by the consent and cooperation of the following at the Seneca Army Depot: Colonel Thomas A. Mort, commanding officer; Major David Bertocci, provost marshal; Joseph M. Comernisky, chief of security police; Jacob Nowak, Captain Paul Middlebrook and Lieutenant Fred Tanneberger, conservtaion officers. Special thanks are extended to William T. Hesselton and Stuart Free of the New York State Department of Environmental Conservation and Dr. Robert E. Chambers of the State University College of Environmental Science and Forestry for their advice and encouragement. The author also wishes to thank Dr. George Mattfeld of the College for his inspiration and Dr. Donald F. Behrend and Dr. Edward O. Price of the same institution for reviewing the manuscript.

Table 1. Estimates of Mortality Among White-tailed Deer Fawns

Locality	Authority	Estimated mortality (per cent)	Remarks
Indiana	White (1968)	11 (loss of ova)	derived from embryo counts
Maine	Banasiak (1961)	30	analysis of harvest statistics
Michigan	Eberhardt (1960)	30	derived from embryo counts, fawn : doe ratios and yearling : adult ratios
Michigan	McNeil (1962)	28	population reconstruction
Michigan	Verme (1962)	7-90	nutritionally deprived does
Missouri	Murphy and Coats (1966)	42, 27 and 0	penned does fed three different protein diets
Mississippi	Noble (1960)	20.5	drived from embryo counts and fawn : doe ratios
New York (Seneca Army Depot)	Hesselton et al. (1965)	11.5 (prior to management) 28.7 (during management)	population reconstruction
Nova Scotia	Dodds (1963)	25	analysis of harvest statistics
Oklahoma	Hair (1968)	25-50	data from experimental areas; intensive parasite involvement
Texas (Welder Wildlife Refuge)	Cook et al. (1967, 1971)	71-72	based on radiotelemetry of neonatal fawns; extensive predator involvement
Texas (Llano Basin)	Teer et al. (1965)	12 (loss of oocytes) 1 (prenatal) 11 (neonatal)	derived from embryo counts
Virginia (Radford Army Amunition Plan)	McGinnes and Downing (1970)	8.3 normal fawns) 56 (deformed or atypical in color)	Observation of marked fawns
Wisconsin	Dahlberg and Guettinger (1956)	30	

ably in different localities as evidenced in the results of the investigations summarized in Table 1.

The purpose of the present study was to estimate the degree of fawn mortality in a dense but relatively secure and healthy wild population as a baseline for comparison with data for other situations. Further objectives were to define the period of highest fawn mortality and to determine the rearing success of does of different ages and prelage color.

The design of the study differed from that of most studies of fawn mortality in that the fawns were neither handled nor marked, hopefully eliminating mortality induced by such procedures as suggested by Cook et al. (1971) and White et al. (1972). Fawns were later identified by the doe with which they associated. This was based on two assumptions: (1) does tend not to abandon or adopt fawns (Severinghaus and Cheatum, 1956; Swenson, 1972); and (2) family groups remain intact at least through the summer (Caton, 1877; Hawkins and Klimstra, 1970).

The work was done on the Seneca Army Depot located near Romulus in central New York. The Depot consists of approximately 10,000 acres of once-fertile farm land, of which 7,500 acres constituted deer habitat (Hesselton et al., 1965). According to the same author, approximately 80 per cent consisted of old-field herbaceous and shrubby communities,

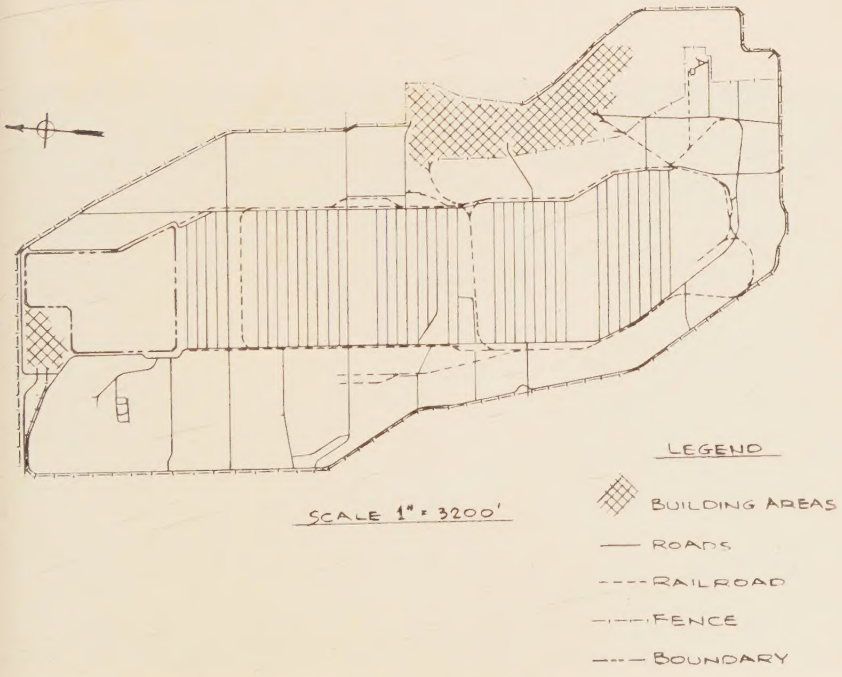

Figure 1. Road plan of Seneca Army Depot.

the remaining 20 per cent being comprised of woodlots and hedgerows. An extensive road system designed to facilitate security and material handling (Figure 1) provided excellent access to most of the ammunition-storage area. The entire tract was enclosed by a 7-foot barbed wire and chain link fence. Although not unsurmountable, the fence greatly discouraged deer dispersal.

When the Depot was established in 1942, construction of a perimeter fence enclosed an estimated 20 to 40 white-tailed deer (Hesselton et al., 1965). In the absence of hunting, the population quickly grew from this nucleous to some 2,500 by 1957. Thereafter, deer were harvested annually to maintain a population compatible with safe Depot operations and habitat conditions. The frequency of a white-pelage genotype (not albino, Hesselton, 1969), either present in the founding population or a product of mutation, increased in this sanctuary-like environment (Figure 2). At the time of this study, the deer population at the Depot consisted of 700 to 750 animals, of which approximately 25 per cent were white (Hesselton, 1973). The brown deer and white deer at the Depot were of comparable physical condition and perhaps equal to the best in New York State (Hesselton, 1969).

Figure 2. A white doe nursing her brown fawn.

METHODS

The methods used in various aspects of the study are described separately.

CAPTURING FEMALES

In the winter and spring, prior to the fawning period, females were captured by remote injection of succinylcholine chloride, brand name Anectine (Burrough Wellcome and Co., Research Triangle Park, N.C.). The drug was delivered to the deep muscle of the deer's rump and hip via a "C" series Pneu-Dart (Pneu-Dart, Inc., Williamsport, Pa.). The "C" series Pneu-Dart is simiar to the "P" series described by Liscinsky et al. (1969). The darts were fired from a 50-caliber powder-charged Cap-Chur gun (Palmer Chemical and Equipment Co., Inc., Douglasville, Ga.). The Cap-Chur equipment was selected because it could be operated by an individual worker—a necessity at this security depot.

Deer judged to be juveniles (6 to 11 months old) were injected with a 6-milligram drug load or an average dose of 7.67 milligrams per 100 pounds of body weight. Larger deer received an 8-milligram load or an average dose of 6.45 milligrams per 100 pounds of body weight. Deer were injected after dark as well as during daylight, either from a vehicle or from concealment. A rifle-mounted aviation landing lamp (Westinghouse 45-9/4590-1, 13 volts) was used for sighting and following injected deer at night.

To avoid handling does near term, the capture phase was ended about a month prior to the expected peak fawning period. Hesselton and Jackson (1971) reported that the average fawning date for yearling does in central New York was June 25; older does averaged nearly 2 weeks earlier, June 12. Consequently, the capture of adults was terminated by the end of April and that of yearlings by the last week in May.

MARKING

Captured does were aged by relative tooth wear and replacement (Severinghaus, 1949) and were individually marked with a 4-inch-wide collar of Armortite ATV 18, a vinyl-coated nylon lamination (Cooley, Inc., Pawtucket, R.I.). The collars were either blue, yellow or red, with each color representing an age group, i.e., 1, 2 or 3 and over years, respectively. They were similar in design to the collars described by Phillips and Nicholls (1970). Each collar had two identical 5-inch numerals glued to it with Bondtite adhesive (Cooley, Inc., Pawtucket, R.I.) and sewed with nylon thread. The numerals were positioned so their bases were 15 inches apart and equidistant from the collar's center, thus permitting one numeral to be visible from either side of the animal (Figure 3). Collars

Figure 3. A collared doe showing numeral visible on near side; similar numeral visible on opposite side.

were fastened around the doe's neck with two Pop-rivets (U.S.M. Corp., Reading, Pa.). A third rivet fastened both ends of a 3½ by ¾-inch leather strap, forming a loop that supported a 2 by 2⅜-inch sheep bell.

Observations

The low and dormant vegetation of winter and early spring and the extensive road system provided excellent opportunity for observation over most of the 7,500-acre ammunition storage area which constituted the deer habitat on the Depot. Observations were made daily, or nearly so, between December 1971 and September 1972 by driving slowly along the roads. Nearly half the marked does were thus observed each day. As the vegetation grew taller and more dense, it became necessary to alter this technique. Observations were then made from the numerous ammunition bunkers, which provided excellent, elevated stands.

By taking advantage of behavioral patterns of the doe as described by Downing and McGinnes (1969) and White et al. (1972), young fawns were readily observed. In this way family group definition, i.e., the first sighting of a doe and her new fawn(s), could usually be established within a few days of birth. Nocturnal observations were aided by an aviation landing lamp or by a starlight night-vision scope. This optical instrument, similar to that described by Swanson and Sargent (1972), operates on a light-intensification principle.

Fawn : doe ratios for both marked and unmarked does were obtained from roadside observations during late summer (September 1972) to evaluate the effect of the capture and marking of gravid does on fawn survival.

FAWN MORTALITY

Two phases of fawn mortality were examined. The first, prenatal-neonatal mortality, was represented by the difference between the number of expected births per doe and the observed number of fawns per doe at the first family group definition. Expected births, i.e., embryo counts, were determined by examining 145 female genital tracts, 140 collected during three special post-season hunts (December 18, 1971, January 15, 1972 and January 22, 1972) and five obtained as a result of capture-associated mortalities. These tracts represented 39 to 42 per cent of the estimated number of females in the fall population. They were classified according to the age of the doe and preserved in 10 per cent formalin. Age-specific embryo counts were assumed to be similar for both marked and unmarked does. Also, Hesselton (1969) previously reported that reproductive success of white does was comparable to that of brown does of similar age. Consequently, the tracts of white does (13) were not separated from those of brown does (132).

The uterus was opened and examined for fetuses or extra-embryonic tissue as evidence of pregnancy. Fetus numbers, sex, location (one or both horns of the uterus), and crown-rump or forehead-rump measurements (Armstrong, 1950) were recorded. Fetuses were then aged according to a table prepared from data given by Cheatum and Morton (1946) and Armstrong (1950). Fetus age and collection date were used in conjunction with a gestation-period table (New York Federal Aid in Fish and Wildlife Restoration Project W-89-R, unpublished) to determine the date of breeding and the projected birth date in each case. From this information, mean fawning periods of June 29, June 2 and June 4 for does 1, 2 and 3 or more years old,[2] respectively, were calculated, together with median fawning periods of July 2, June 3 and June 3.

Statistical comparisons were made using chi square for binomial data, while other discrete data were tested by a standard *t*-test following a normal score transformation. The level of significance chosen for all testing was 0.05.

The second phase of fawn mortality, postnatal, consisted of reductions in the observed number of fawns in previously defined family groups. This was based on the assumption that a doe and her fawns remained together as a family group until autumn.

[2] Throughout this paper, age with respect to breeding does represents age at the next fawning season.

RESULTS

The information obtained indicates that the capture and marking of gravid does did not affect the survival of their fawns and that data for marked and unmarked does were comparable.

CAPTURE AND MARKING

A total of 63 deer were successfully immobilized, although five of them (8 per cent) were lost through various capture-associated mortalities. Initially, successful capture required an average of 11.2 man hours of hunting per deer. However, as the study progressed success improved, reducing the effort required to about 8 man hours per deer. Of those released, 46 were marked does, constituting approximately 20 per cent of the overwintering female population. The remaining 12 deer were antlerless males. The distribution of the marked does, by color and age, is given in Table 2.

TABLE 2. DISTRIBUTION, BY AGE AND COLOR, OF DOES MARKED AT THE SENECA ARMY DEPOT IN 1972

	Age (years)*			
Color	1	2	3 or more	Total
Brown	7	5	13	25
White	8	6	7	21
Total	15	11	20	46

* Represents age at next fawning season.

Collar and bell retention was extremely high; no collars and only one bell were lost during the study. Bells proved to be an effective aid in locating marked does, being audible at 400 yards in most situations. There were no indications that the collar and/or bell affected the behavior of the experimental does.

REPRODUCTION

Expected births, i.e., embryo counts, were assumed to be similar for both marked and unmarked does, and hunter-killed specimens collected during the same breeding year were considered to constitute a representative sample according to age group. Embryo counts for the 145 genital tracts examined averaged 0.295, 1.630 and 1.857 per doe for those 1, 2 and 3 or more years old, respectively (Table 3). Palpation of immobilized (marked) does indicated similar ($P>0.05$) embryo frequencies of 0.21, 1.67 and 1.80 per doe for the three age groups, respectively, thus supporting the assumption that reproductive rates among the marked and unmarked deer were comparable.

TABLE 3. REPRODUCTIVE RATES (IN TERMS OF EMBRYOS PER DOE) FOR HUNTER-KILLED DEER, BY AGE AND DATE OF COLLECTION, AT THE SENECA ARMY DEPOT, 1971-72

Age* (years)	Embryos per doe§			Total
	December 18	January 15	January 22	
1	0.09 † (11)	0.462† (13)	0.300† (20)	0.295 (44)
2	1.667† (6)	1.800† (15)	1.520† (25)	1.630 (46)
3 or more	1.350† (20)	1.800† (15)	1.900† (20)	1.857 (35)

* Represents age at next fawning season.
§ Data are averages for each collection date; figures in parentheses represent number of specimens.
† Within same age group, these values are similar ($P>0.05$).

FAWN MORTALITY

The design of this study prohibited the separation of prenatal and neonatal mortality. Therefore, the two are considered as one.

PRENATAL—NEONATAL Statistical comparison of embryo counts with fawn counts at the first family group definition revealed differences ($P<0.05$) of 22 and 19 per cent for does 2 years old and 3 or more years old, respectively (Table 4). Due to the low productivity of yearling does,

TABLE 4. EXPECTED AND OBSERVED FAWN : DOE RATIOS, BY AGE AND TIME PERIOD, AT THE SENECA ARMY DEPOT IN 1972

Does examined		Embryos or fawns per doe*		
Age§ (years)	Number	Expected† (June)	Observed	
			June††	September
1	15	0.295‡ (4)	0.133‡ (2)	0.133‡ (2)
2	11	1.630 (18)	1.273‡ (14)	1.273‡ (14)
3 or more	20	1.857 (37)	1.500‡ (30)	1.450‡ (29)

* Figure in parentheses represent number of embryos or fawns.
§ Represents age at next fawning season.
† Derived from embryo counts.
†† Some records obtained as late as 2 weeks after birth.
‡ Within same age group, these values are similar ($P>0.05$).

an insufficient number of progeny were obtained for valid statistical comparison. However, the 15 yearlings in the sample produced half the anticipated four fawns.

Family groups, i.e., does with fawns, were defined during the first two weeks after the fawns were born. Fawn : doe ratios for families shortly after parturition did not differ significantly from ratios secured later (Table 5). Neonatal mortality was not documented after the first family group definition.

Table 5. Number of Fawns Per Doe For Family Groups Defined at Three Intervals During the First Two Weeks After Birth at the Seneca Army Depot in 1972

Interval after birth (days)	Number of fawns	Fawns per doe*
0- 3	14	1.60
4- 7	12	1.50
8-14	20	1.54

* All values similar ($P>0.05$).

Obtaining data by palpation was hindered by the difficulty of feeling small embryos (less than 285 millimeters long or 126 days old). However, six embryos detected in this way when the does were being marked were not observed at the first family group definition. This loss (consisting of one, two and three embryos) involved three does 1, 2 and 3 or more years old, respectively.

Fawn survival appeared to be independent of the dam's color. Data for 25 brown and 21 white does yielded similar ($P>0.05$) average fawn counts of 0.96 and 1.05, respectively.

Postnatal During the postnatal period only one fawn failed to be reobserved with its family group. This brown fawn was last seen about 6 weeks after birth. During the following two months the fawn's dam and sibling were frequently observed, but it never reappeared. Therefore, it was concluded that the missing fawn had not survived. No additional fawn mortality was observed. Thus fawns attaining the age of 2 weeks appeared to be quite secure, experiencing only 2 per cent mortality during the remaining summer months (Table 4).

Effect of Marking on Gravid Does Unmarked family groups were observed on 282 occasions during September 1972, and included 296 fawns or an average of 1.05 per doe. Marked does, of a similar age distribution, were accompanied by an average of 1.02 fawns per doe. Testing these ratios by chi square showed no significant difference, indicating that the capture and marking of gravid does did not affect the survivial of their fawns.

DISCUSSION

Juvenile mortality is often substantial among white-tailed deer (Table 1). Nutritional deficiency (Verme, 1962; Murphy and Coates, 1966) and predation (Knowlton, 1964; Cook et al., 1971) are believed to be major decimating factors in certain populations. The degree of nutritional deficiency and/or predation may vary annually and between situations; thus the magnitude of prenatal-postnatal losses depends upon the circumstances unique to each population. Quantitative measurement of these decimating factors is beyond the scope of most deer management

programs. Consequently, measurement of baseline fawn mortality (where deer are well nourished and free from predation) would be a useful yardstick against which to compare other fawn mortality rates. The deer population at the Seneca Army Depot was relatively free of human and predator interferences and existed on a relatively high nutritional level. Yet, a prenatal-postnatal fawn mortality of nearly 24 per cent was noted during this study.

Prenatal—Neonatal Mortality

Although all family-group definitions were not completed until the end of the second week after the fawns were born, there appears to be a strong indication that most or all prenatal-neonatal mortality occurred prior to or immediately following parturition. Families defined during the first three days had fawn : doe ratios statistically similar to those of families defined later, suggesting that fawn mortality was insignificant after three days following birth.

Although this research was not designed to defined the agents of fawn mortality, several potential causes may be discussed.

Embryo Resorption Although prenatal and neonatal losses were not differentiated, the evidence available from this and other studies suggests that early gestation (the first 100 days) is a period of high fetal survival. No resorbed, dead or misformed enbryos were observed by the author among the 177 fetuses taken during early gestation. Similar collections of 3,575 embryos by Hesselton and Jackson (1971) in New York revealed only 0.44 per cent mortality among single embryos, 1.89 per cent among twins and 6.40 per cent among triplets. Teer et al. (1965) indicated that prenatal mortality from resorption and other causes amounted to less than 1 per cent among the 787 fetuses they examined. In two earlier studies, of mule deer (*Odocoileus hemionus*), Taber (1953) and Robinette et al. (1955) reported a low fetal mortality of 2 per cent.

Verme (1962), in studying captive white-tailed deer held on deficient diets, observed a fetal mortality of 9 per cent at mid-gestation and an additional 8 per cent during the final stages of gestation. These results appear contrary to the findings of Taber (1953) and Robinette et al. (1955) which indicated a subsidence of fetal mortality after mid-gestation. It may, therefore, be inferred that the deer at the Depot, which according to Hesselton et al. (1965) were vigorous and well nourished, did not sustain substantial prenatal mortality during the final stages of gestation.

External palpation was of value only to determine the number of fetuses in utero. The reliability of such examinations increases as the fetus grows, reaching a reasonable level of confidence by the 150th day. However,

even after 75 per cent of the gestation period had passed, the status of developing fetuses could not be determined. Later collections and the use of more sophisticated techniques, such as radiographic examination as employed by Verme et al. (1962), would be needed to document the extent of prenatal mortality during the latter stages of gestation.

Dystocia Difficult parturitions are extremely hard to document among wild, free-roaming deer. Robinette et al. (1973), dealing with captive mule deer, reported three fawn deaths (1.3 per cent) resulting directly from dystocia. However, injuries sustained during such parturitions may result in mortality shortly thereafter, making it obscure whether the difficult birth itself or the injuries was the actual cause of death. As Reid et al. (1964) observed among Holstein cows, the first birth is probably the most critical. Dystocia was not observed during the present study, and the similarity in the number of fawns reared by does giving birth for the first time (yearlings and many 2 year olds) and does that had been bred before (3 or more years old) indicated that dystocia is not a major agent of fawn mortality in wild populations. Females susceptible to having difficult and injurious births would tend to suffer higher mortality, as well as contribute fewer progeny to the population, than other does and would thus be eliminated through natural selection.

Postnatal Mortality

Postnatal mortality among fawns on this area where they were largely free from human interference and most predators was minimal. Nevertheless, predation, weather and accidents were potential causes of loss.

Predation Predation on deer was rarely documented on the Seneca Army Depot. The only predator on the area capable of taking a fawn was the dog (*Canis familiaris*), 43 free-roaming dogs being seen during the study. Several were observed chasing adult deer, and one was known to have killed a large number of sheep on an adjacent farm.

The cover patterns of the reverting old fields and the habits of nursing does created a situation that could lead to extensive fawn chasing and predation. The only cover in these fields during the early summer, before the herbaceous vegetation had grown tall, were scattered thickets of panicled dogwood (*Cornus racemosa*) which became fully leaved during May and June, the peak fawning time. The crowns of these clumps formed a visually impenetrable dome. However, their interiors were easily penetrated by deer, and does were observed to use only these islands of cover when hiding their fawns between between nursings. Dogs following a doe's scent might accidentally find her hidden fawn. After several such positive experiences, a few dogs may learn to search such clumps and in this manner become efficient fawn-finding predators. If dogs were finding

fawns in this way, one would expect cryptic coloration to be of negligible protection to fawns. Thus survival rates for brown fawns and white fawns should be similar, as was the case during this study.

Weather The month of June 1972 was particularly inclement for neonatal fawns. Pack (1972), a climatologist for New York, wrote "In many respects the month's weather rewrote the climatological records for New York State." Rain accompanying tropical storm Agnes amounted to over 8 inches on the study area in a 5-day period between June 20 and 25; over 11 inches were recorded for the month. Excessive cloudiness and abnormally low temperatures, averaging nearly 4° F. below normal, characterized the month. Yet, young fawns were apparently able to tolerate this excessive wetting and cold, for only one failed to be re-observed during or after the extreme weather of late June.

Accidents Vehicular accidents rarely involve very young fawns due to their sedentary behavior. However, such accidents may orphan young fawns and perhaps cause their death. For fawns that have not been weaned, the critical time for orphan survivial may extend to the end of the third month of life (Severinghaus and Cheatum, 1956). Occasionally, very young fawns survive either through rare cases of adoption or by successfully adapting to a diet of natural foods (Swenson, 1972).

One experimental doe was killed and her 1-month-old fawn orphaned by a vehicle accident. Quite by coincidence, this was the only fawn of a marked doe that was captured and marked at birth. This fawn was repeatedly reobserved and was never seen to associate with another deer. It was killed by a gunner the following winter and appeared normal in all respects.

Records kept by the safety officer at the Depot (M. J. Way, personal communication, 1975) indicate that deer-vehicle accidents occurred at the rate of five or six a month during June and July (a 10-year average). The frequency of this loss would vary with the density of the deer population and the density of vehicular traffic. Consequently, reduced speed limits and traffic within the study area kept accidental deaths to a minimum.

Other accidents may befall fawns. McGinnes and Downing (1970), working at a similar army installation in Virginia, reported that 14 per cent of all documented mortality occurred through accidental falls from artificial structures. Such losses were not noted during the present study and are believed to be of minimal importance.

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MOVEMENTS OF WALLEYES TAGGED IN EASTERN LAKE ERIE[1]

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ABSTRACT

In May, October and November of 1968, 2,456 walleyes of various ages were captured, tagged and released in eastern Lake Erie to determine seasonal movement of walleyes in that basin and the degree to which they intermingled with fish of the central and western basins. From 1968 to 1971, 275 of the tagged fish were recovered. Walleyes tagged in the spring on spawning grounds near Barcelona (N.Y.) moved northeasterly along the shore soon after spawning and spent the summer near the Buffalo-Niagara River Inlet area. Later returns indicated that they then reversed their direction of travel in late summer and fall and followed the shoreline back toward the spawning grounds off Barcelona. Young fish, tagged in the fall, also showed this pattern the following year. Westward movement into the central basin was insignificant, and no recoveries were reported from Canadian waters. Therefore, it is concluded that walleye populations in the United States waters of eastern Lake Erie are geographically separate from those in the western basin and that their management should be based on this inference.

The walleye (*Stizostedion v. vitreum*) has been an important food and sport fish in Lake Erie for decades. Most of the commercial catch has historically come from the western basin of the lake, where United States landings reached a record high of 4.3 million pounds in 1956. Thereafter, the annual yield decreased, falling to less than 0.2 million pounds in 1969. In contrast, the walleye catch from the eastern basin in New York waters followed an upward trend during this period, marked by 18,000 pounds in 1956 (at that time the highest since 1940), 90,000 pounds in 1959, 107,000 pounds in 1963 and a peak of 121,000 pounds in 1967. A corresponding rise in the catch per unit of effort, while total fishing effort remained stable, indicates that the eastern stock did become more numerous as the western stock declined.

These contrasting trends suggest that the western and eastern walleye populations in the lake are geographically discrete. In partial support of this thesis, a study of the population in the western basin (Wolfert, 1963) revealed that walleyes tagged and released as yearlings did not move eastward in later years. Before the present study, similar information on seasonal movements of eastern basin walleyes was unavailable.

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[1]Contribution No. 530 of the Great Lakes Fishery Laboratory of the U.S. Fish and Wildlife Service, Ann Arbor, Michigan 48105. The authors thank the many commercial and sport fishermen who cooperated by returning tags and providing associated information, as well as Edward Brown and LaRue Wells of the U.S. Fish and Wildlife Service for their constructive review of the manuscript.

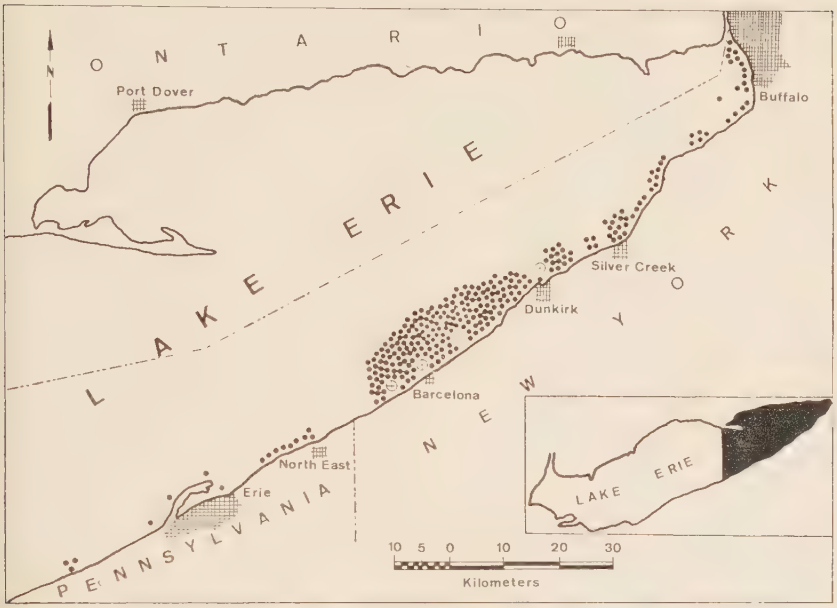

Figure 1. Map of eastern Lake Erie showing localties of release (circled cross) and recovery (solid circle) of tagged walleyes.

This paper describes the results of a tag-recapture experiment by the U.S. Fish and Wildlife Service to determine seasonal changes in the geographic distribution of walleyes in eastern Lake Erie and the extent to which the fish intermingle with central or western basin stocks. Such information would be particularly useful in interagency efforts to develop a sound biological basis for managing walleye stocks in Lake Erie.

MATERIALS AND METHODS

Walleyes for this study were taken with gillnets fished under contract by commercial fishermen near Barcelona and Dunkirk (N.Y.) in May, October and November of 1968 (Figure 1). The spring sample, caught on the spawning grounds, consisted of 1,649 walleyes from large-mesh gillnets (4½ to 5 inches, stretch measure) and 50 from small-mesh nets (2¾ to 3⅛ inches). More than 85 per cent of these fish were in age groups IV to VI. Most (77 per cent) were males, which remain on the grounds longer than females and consequently are more vulnerable to capture (Table 1). The entire fall sample of 807 walleye was taken in small-mesh nets to provide better representation of smaller and younger fish, which were poorly represented in the May collections. Almost all (91 per cent) of these fall fish were in age groups II and III (Table 2).

Table 1. Walleyes Tagged and Released in Eastern Lake Erie in May 1968 According to Age, Sex and Length

Age group	Sex			Tagged		Length (millimeters)	
	Male	Female	Undetermined	Number	Per cent	Average	Range
II	4	0	7	11	0.6	343	328-362
III	38	28	18	84	4.9	453	405-488
IV	574	189	58	821	48.4	487	408-565
V	261	61	26	348	20.5	514	425-650
VI	230	29	18	277	16.3	545	441-681
VII	65	27	0	92	5.4	582	442-695
VIII	24	12	4	40	2.4	617	533-741
IX	7	9	1	17	1.0	664	567-762
X	2	5	0	7	0.4	704	606-788
XI	0	2	0	2	0.1	752	722-781
Total	1,205	362	132	1,699	100.0	xxx	328-781

Table 2. Age and Length Distribution of 807 Walleyes Tagged and Released in Eastern Lake Erie in October and November of 1968*

Age group	Tagged		Length (millimeters)	
	Number	Per cent	Average	Range
II	594	73.6	325	295-374
III	144	17.9	422	389-458
IV	48	5.9	456	418-523
V	17	2.1	510	445-589
VI	4	0.5	592	556-612
Total	807	100.0	xxx	295-612

* Sex undetermined.

Walleyes marked in the spring were tagged with dart-type tags (Wolfert, 1963) and those in the fall with Floy model FT-67 tags. Fish suitable for tagging were removed from the gillnets (by cutting the webbing) and placed for a short period before tagging in a prophylactic dip of 3 ppm acriflavin and 0.1 ppm malichite green. Each fish was measured, its sex was determined visually when possible, and a scale sample was removed. Only fish in apparently good condition were tagged.

The recoveries consisted entirely of voluntary returns by fishermen who were encouraged to report tags by posters placed in bait stores and marinas in the United States and Ontario, by personal contracts and by periodic news releases in cities along the southern shore of the lake. As an added incentive, a $1 reward was paid for each tag returned.

TAG RECOVERIES

During the years 1968 to 1971, 275 tags, representing 11 per cent of the walleyes marked in 1968, were returned by commercial and sport

fishermen; none was reported after 1971. Returns were higher for the adults tagged in May (14 per cent) than for younger fish tagged in October and November (6 per cent). This difference was most likely due to differential survival related to the size of fish tagged and to the water temperature at the time of tagging, i.e., large size and lower water temperatures presumably favored survival. In the spring, most of the fish tagged were large (Table 1) and the water temperature was low (7.2° to 9.4° C.). In contrast, in the fall the fish were smaller (Table 2) and water temperatures ranged from 10.6° to 15.6° C. The different types of tags used in the spring and fall may also have affected the relative chances of recovery.

A difference in the percentage of returns by sex was also noted, males apparently being more susceptible to recapture. Of 1,567 known-sex walleyes tagged in the spring (Table 1), about 16 per cent of the males were recovered, compared with less than 8 per cent of the females. Of the sexed fish recaptured, 87 per cent of the males and 71 per cent of the females were taken by the commercial fishery.

Among the 76 tagged walleyes recaptured in 1968, 10 were taken in May, all near the tagging site (Table 3). A definite move to the north-

TABLE 3. NUMBERS OF WALLEYES TAGGED IN EASTERN LAKE ERIE AND RECOVERED BY COMMERCIAL AND SPORT FISHERMEN DURING DIFFERENT MONTHS, 1968-1971*

Month	Year of recapture		
	1968	1969	1970
March	0	1	0
April	0	102	12
May	10	42	0
June	17	4	3
July	14	13	3
August	9	9	0
September	7	2	0
October	5	1	1
November	13	2	0
December	1	0	0
Total	76	176	19

* Four walleyes were also taken in May 1971 by commercial fishermen from the spawning grounds near the release site.

east was evident in June, as 14 of 17 recaptures during the month were made between Dunkirk and Silver Creek and two were taken near Buffalo about 50 miles from the release point. Only two tags were returned by anglers during May-June. As summer progressed, however, commercial fishing decreased and angling increased. As a result, 25 of the 30 tags recovered from July through September were returned by

sport fishermen. Over half of these were taken between Silver Creek and the Niagara River Inlet. The first recaptures (eight fish) taken west of the release area were recovered near Erie and North East (Penn.) during the three months. During October-December, 19 marked fish were caught between the release area and Silver Creek.

Of the 175 recoveries in 1969 (Table 3), only one was made in March —off Lorain, Ohio, 150 miles southwest of the release area. This represented the longest movement from the release site of any recaptured walleye and was the first of four tagged fish taken in the central basin. The 102 tagged walleyes caught by commercial gear in April were the largest number taken in a single month; 65 were retaken in the release area, and all but four of the 37 others were taken within 15 miles to the east.

Of the 42 tagged fish reported in May 1969, 23 were from the release area, while movement eastward was indicated by 13 recaptures near Dunkirk and six between Silver Creek and Buffalo. Anglers accounted largely for another 26 recaptures in June-August (Table 3), half of which were taken near Buffalo. During September-November, three tagged walleyes were caught near Erie.

In 1970, 19 returns were reported (15 in April and June), all in the release area. Only four marked fish were recaptured during 1971, all in May and near the spawning grounds. No further recoveries have been reported.

SEASONAL MOVEMENTS

Similar temporal trends in recovery of the tagged walleyes during the three years (Table 3) permit some generalization on the seasonal movements of eastern basin walleyes. Fish spawning in nearshore waters off Barcelona during May moved in a northeasterly direction along the shore soon after spawning, and some traveled as far east as the inlet of the Niagara River near Buffalo within a month. Later tag returns suggest that these fish then reversed their direction of travel in late summer and fall and followed the shoreline back toward the Barcelona spawning grounds. The younger fish tagged in the fall of 1968 also showed this pattern of movement the following year.

Indications of any extended westward movement into the central basin were insignificant among walleyes of all age groups. Although the interpretation of tag returns can be influenced greatly by the distribution of recovery effort, the authors believe that the Pennsylvania commercial fishing industry was large enough to have taken tagged walleyes in the central basin had they been present. Commercial fishing in both Pennsylvania and New York is confined mainly to waters within a few miles of the shoreline. Pennsylvania has about 51 miles of shoreline and New York about 77. During the period 1968 to 1971, 12 to 14 licensed commercial fishermen were operating in Pennsylvania and 19 to 21 in New York.

Other characteristics of the lake's total walleye stock also suggest that the eastern and western populations remain geographically, and therefore genetically, separate. Walleyes from eastern Lake Erie grow much slower (D. R. Wolfert, unpublished data), mature at an older age and are less fecund (Wolfert, 1969).

Moreover, indications are that old fish are far better represented in samples of the eastern basin population than in samples of the western basin population. Year-class success has varied tremendously in western Lake Erie. Good hatches were the rule in most years before 1955 (Parsons, 1970), but from 1956 to 1976 year-class success fluctuated widely, being fair in 1959, 1961 and 1965, relatively strong in 1962, 1972 and 1974, and poor in the other years (Great Lakes Fisheries Commission, 1976). Conversely, year-class strength in the eastern basin population remained comparatively stable until the early 1970's.

Tag returns revealed that the fish had a strong tendency to return each year to their spawning reefs. In April and May, during the years 1969 to 1971, 62 per cent of the tagged fish were caught at the release sites, while 34 per cent were captured within 15 miles of those sites (most within 5 miles). Strong homing behavior has also been reported for other walleye populations, e.g., by Stoudt (1939), Eschmeyer and Crowe (1955), Crowe (1962) and Crowe et al. (1963).

The finding that recoveries of walleyes tagged in New York waters of Lake Erie were confined mainly to the nearshore waters of New York is of considerable significance to fishery managers. Although 5 per cent of the recoveries were made in Pennsylvania waters, they were within the eastern basin and less than 30 miles from the release point. No recoveries were reported from Canadian waters, and less than 2 per cent of the returns were from the central basin. Therefore, it is concluded that walleyes in the United States waters of eastern Lake Erie are geographically separate from populations in the western basin and that management should be based on this inference.

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EFFECT OF A FOUR-YEAR CLOSURE OF TRAPPING SEASON FOR BEAVER IN FULTON COUNTY

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ABSTRACT

Trapping for beaver in Fulton County was prohibited from 1969 to 1972, and the effects of the closure on the beaver population were evaluated. A substantial increase in beaver abundance insued, as evidenced by a calculated gain in the number of active colonies from 45 to 184. Beaver damage complaints also increased, plugging of road culverts being the principal type, but until the number of colonies exceeded 150 the cost of servicing complaints was considered reasonable. It was concluded that an occupancy of 30 to 40 per cent of the potential colony sites would be desirable and that trapping may be permitted under regulations designed to maintain the beaver population at that level.

Information concerning beaver abundance indicated that the population in the Northern Zone part of Fulton County was at a very low level in 1968 and that trapping was probably the principal cause. Consequently, trapping for beaver in that part of the county was prohibited from 1969 through 1972. However, due to an error in drafting the regulations for 1969, beaver trapping was prohibited in the Southern Zone part of the county also. It was subsequently decided to leave the latter area closed during the following three years and to evaluate the effects of the closure on the beaver population throughout the county.

Fulton County has a total land area (i.e., exclusive of lakes, ponds and reservoirs of over 40 acres and streams more than ⅛ mile wide) of 497 square miles or 318,080 acres (New York State Comptroller, 1961). It lies within two major ecological sections, the Mohawk and the Adirondack Foothills as described by Dickinson (1969), the proportions being about 56 and 44 per cent, respectively. The relationship is illustrated in Figure 1.

The Mohawk section comprises 278 square miles in the county and is characteristically gently rolling to hilly. Between 55 and 60 per cent is in woodland (Scott, 1958). In rural areas, approximately 50 per cent of the land is devoted to farming, with less than 30 per cent of the farm acreage being wooded. Most of the land is in private ownership. Access is considered good, with an average of 330 acres per mile of highway (Dickinson, 1969).

The Adirondack Foothills section comprises 219 square miles. Its topography varies from gently rolling to moderately rough, with some

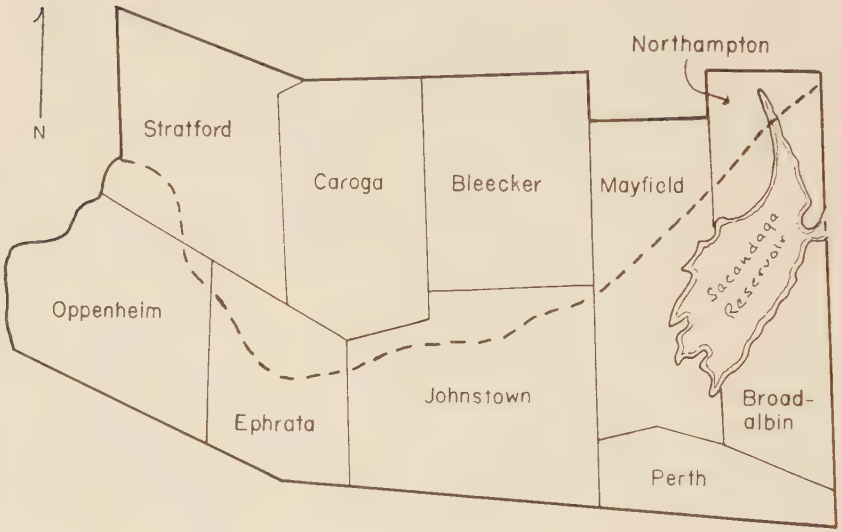

Figure 1. Map of Fulton County showing town boundaries and the two major ecological sections: Adirondack Foothills above dash line and Mohawk below.

mountains exceeding 2,000 feet in elevation. Between 85 and 90 per cent is in woodland, and less than 10 per cent is farmed (Scott, 1958). Approximately 36 per cent of the land is in State ownership and is part of the Forest Preserve. Most of the area is moderately accessible, with an average of 770 acres per mile of highway (Dickinson, 1969).

PROCEDURE

It was planned that an aerial survey of the distribution and abundance of beaver in the county would be made in the fall of 1969 and that similar surveys would be made in 1971 and 1972 to ascertain any changes that occurred. However, it became impossible to survey the entire county each year. The surveys were conducted on a complete coverage basis, as favorable flying conditions permitted, with only those colonies exhibiting fresh food caches being counted as active.

For comparison, the number of potential beaver colony sites was determined from aerial photographs. Photographs taken in 1957-58, 1968 and 1971 were used[1], all of which had a scale of 4 inches to the mile. For the Adirondack Foothills section of the county, the method described by Dickinson (1971) was satisfactory for identifying potential sites. However,

[1]The aerial photographs for 1957-58 and for 1971 were taken for the N.Y.S. Board of Equalization and Assessment by Abrams Aerial Survey of Lansing, Mich. and by American Air Surveys, Inc. of Pittsburgh, Pa., respectively. Those for 1968 were taken by the U.S. Department of Agriculture.

for the Mohawk section, where beaver populations had been low or absent for a long time, a considerable number of colonies were observed in 1971 where the aerial photographs (1968) showed no evidence of past occupancy. Therefore, for this section, an alternative method was used; potential sites were identified on the basis of watershed, stream gradient and vegetation. Although this method leaves much more room for individual judgment, it is felt that the results are more meaningful than if old beaver occupancy were the only criterion used.

The number of beaver nuisance complaints and the estimated cost of servicing them were recorded for the periods prior to and during the time the trapping season was closed to determine whether or not such complaints increased and, if so, whether efforts to increase beaver abundance are economically justified. The types of complaints were also recorded to determine if recommendations might be made to eliminate them.

FINDINGS

The aerial survey in the fall of 1969 was not completed due to weather conditions. However, the part of the county north of Route 29 and west of Route 10 was covered, and 17 active beaver colonies were observed. In 1971, the entire county was covered, and 57 colonies were noted in the area that had been surveyed in 1969. In 1972, the survey was nearly completed[2], and the corresponding number of colonies was 75. The data

Table 1. Number of Active Beaver Colonies and Proportion of Potential Sites Occupied in 1969, 1971 and 1972 in the Part of Fulton County That Was Surveyed in All Three Years

Town	Number of potential sites	Active colonies							
		1969		1971			1972		
		Number	Per cent*	Number	Per cent*	Change (per cent)	Number	Per cent*	Change (per cent)
Caroga§	23	3	13.0	3	13.0	0.0	12	52.2	+400.0
Ephrata§	17	0	0.0	6	35.3	†	7	41.2	+ 16.7
Oppenheim§	34	7	20.6	15	44.1	+114.0	13	38.2	− 13.3
Stratford§	101	7	7.0	33	32.7	+371.0	43	42.6	+ 33.3
Total	175	17	9.7	57	32.6	+235.0	75	42.9	+ 31.6

* Of potential sites.

§ Only parts of these towns were surveyed in 1969, and the figures for 1971 and 1972 represent those parts only.

† Since no colonies were recorded in 1969, no percentage change can be assigned.

[2]Because of bad weather, the following areas (designated according to U.S. Geological Survey quadrangle maps) were not covered: Oppenheim quadrangle, south of Route 29; Peck Lake quadrangle, south of Route 29 and east of Route 116.

are given in Table 1 together with the comparative number of potential sites.

The numbers of active colonies observed in the entire area covered in 1971 and 1972 were 150 and 184, respectively. The data are given in Table 2 according to ecological section and town together with the comparative number of potential sites. In the Adirondack Foothills section 292 potential sites, or about 1.3 per square mile, were recognized. In the Mohawk section, there were 165, or about 0.6 per square mile.

The annual number of complaints regarding nuisance beaver in Fulton County from 1967 to 1972 is given in Table 3 for each ecological section. Following the closure of the trapping season, the numbers increased from

Table 2. Comparison, According to Ecological Section and Town, of the Number of Active Beaver Colonies and the Number of Potential Sites in Fulton County in 1971 and 1972

Town	Number of potential sites	Active colonies				Change (per cent)
		1971		1972		
		Number	Per cent*	Number	Per cent*	
Adirondack Foothills section						
Bleeker	79	27	34.2	35	44.3	+ 29.6
Caroga	70	25	35.7	25	35.7	0.0
Ephrata	5	2	40.0	2	40.0	0.0
Johnstown	7	2	28.6	4	57.1	+100.0
Mayfield	26	5	19.2	5	19.2	0.0
Northampton	4	1	25.0	1	25.0	0.0
Oppenheim§	0	0	0.0	0	0.0	..
Stratford	101	33	32.7	43	41.6	+ 30.3
Total	292	95	32.5	115	39.4	+ 21.1
Adjusted total‡	292	xxx	xxx	117	40.0	+ 23.0
Mohawk section						
Broadalbin	21	3	14.3	3	14.3	0.0
Ephrata	26	12	46.2	12	46.2	0.0
Johnstown	34	9	26.5	12	35.3	+ 33.3
Mayfield	25	12	48.0	23	92.0	+ 91.7
Northampton	3	0	0.0	1	33.3	†
Perth	14	2	14.3	2	14.3	0.0
Oppenheim	39	15	38.5	14	35.9	— 6.7
Stratford	3	2	66.7	2	66.7	0.0
Total	165	55	33.3	69	41.8	+ 25.5
Adjusted total‡	165	xxx	xxx	77	46.6	+ 40.0

* Of potential sites.

§ Only a few hundred acres of the Town of Oppenheim lie in the Adirondack Foothills section.

† Since no colonies were recorded in 1971, no percentage change can be assigned.

‡ Figures for 1972 adjusted to represent number of colonies prior to trapping operations to remove nuisance beaver.

TABLE 3. NUMBER OF COMPLAINTS REGARDING NUISANCE BEAVER IN FULTON COUNTY FROM 1967 TO 1972

Year	Section			
	Adirondack Foothills		Mohawk	
	New	Recurrent	New	Recurrent
1967	0	1	3	0
1968	2	0	2	1
1969	2	0	5	0
1970	2	0	0	1
1971	3	1	8	3
1972	11	7	18	7

three in 1970 to 15 in 1971 to 43 in 1972. Technicians spent 556 man hours handling the 43 complaints in 1972, compared with 147 man hours on the 15 complaints in 1971. At an average of 8 hours per day, this represented 69.5 and 18.4 man days, respectively. Based on annual salary, fixed charges, vehicle cost and travel expense over 220 working days per year, an average cost per day of $63 was calculated. At this rate, the total cost in 1972 was $4,378.50 ($102 per complaint) compared with $1,159.20 ($77 per complaint) in 1971.

The types of complaints in 1971 and 1972 are given in Table 4. Plugging road culverts was the primary cause, with flooding land second and plugging ponds third.

TABLE 4. TYPES OF COMPLAINTS REGARDING NUISANCE BEAVER IN FULTON COUNTY IN 1971 AND 1972

Section	Plugging pond		Plugging road culvert		Flooding land		Flooding camp		Cutting trees	
	1971	1972	1971	1972	1971	1972	1971	1972	1971	1972
Adirondack Foothills	1	3	1	8	0	6	2	1*	0	0
Mohawk	2	5	5	10	4	9	0	0	0	1
Total	3	8	6	18	4	15	2	1	0	1

* Boathouse.

In some instances, nuisance beaver were live trapped and moved to other localities. The disposition of those handled in this way in 1972 is given in Table 5, the number of complaints so handled in the Adirondack Foothills section being 17 and that in the Mohawk section 38.

DISCUSSION

One of the purposes of closing Fulton County to beaver trapping was to determine the extent to which such trapping was a factor in controlling the level of beaver abundance. Data for the part of the county that was

Table 5. Number of Nuisance Beaver Trapped in Fulton County in 1972 and Their Disposition

Town	Number trapped	Disposition			
		Redistributed			
		Within Fulton County		To Hamilton County	Died
		Same section	Other section		
Adirondack Foothills section					
Bleeker	8	3	1	1	3
Caroga	7	1	..	5	1
Ephrata	..	..	..	..	..
Johnstown	..	..	..	..	..
Mayfield	..	..	..	..	..
Northampton	..	..	..	..	..
Oppenheim	..	..	..	..	..
Stratford	2	1	1	..	..
Total	17	5	2	6	4
Mohawk section					
Broadalbin	4	..	1	3	..
Ephrata	1	..	..	1	..
Johnstown	16	2	1	4	9
Mayfield	6	..	..	6	..
Northampton	5	..	1	4	..
Perth	..	..	..	..	..
Oppenheim	4	2	1	1	..
Stratford	2	..	..	2	..
Total	38	4	4	21	9

covered during all three aerial surveys of the present study showed a gain of from 17 to 75 active colonies between 1969 and 1972. To produce this increase, 341 per cent in 3 years, there must have been a substantial increase in the beaver population.

In the 2-year period from 1969 to 1971 the number of active colonies recorded in the same part of the county rose from 17 to 57. If this rate of increase is applied to the data for the entire county as obtained in 1971, the calculated total number of colonies in 1969 is 45, indicating an increase of 105 over the 2 years and of 149 by 1972. This rate of increase seems excessive, but it might have been possible if all the colonies present in 1969 had been full colonies containing both yearlings and kits. With four kits per litter, one colony could expand to five colonies in 2 years.

The proportion of the potential sites occupied by active colonies varied widely between towns, but the averages for the two ecological sections were quite similar, approximately 40 per cent in each case in 1972 (Table 2). However, these data represent fall observations, and earlier in the year some beaver had been removed by nuisance-trapping operations. As shown in Table 5, in the Adirondack Foothills section 17 beaver were trapped of which four died and eight were moved outside this section,

while four of those trapped in the Mohawk section were moved in. Thus the net loss was eight, and, similarly, that for the Mohawk section was 32. Assuming four beaver as representing a colony, there had been two more colonies in the Adirondack Foothills section, and eight more in the Mohawk section, in 1972 prior to the nuisance trapping. Hence, as shown by the adjusted totals in Table 2, the actual degree of occupancy was 40.0 per cent in the Adirondack Foothills section and 46.6 per cent in the Mohawk section.

Although these adjusted values for the two sections in 1972 are not widely different, the rates of change from previous years in the number of colonies did differ substantially, the degree of increase from 1971 to 1972 being 23 per cent in the Adirondack Foothills section compared with 40 per cent in the Mohawk section. It seems probable that the greater increase in the Mohawk section reflected a greater availability of unoccupied sites and better range conditions associated with the fact that beaver had been virtually absent from that part of the county for a long time. However, as indicated in Table 1, growth in the area that was surveyed in 1969 (most of which is in the Adirondack Foothills section) dropped significantly after 1971 when 30 per cent plus occupancy of potential sites was reached. It is felt that an occupancy level of between 30 and 40 per cent would be optimum in this county.

It should be noted that approximately 90 per cent of the active colonies were located in situations recognized as potential sites by the criteria used. The number of potential sites per square mile in the two ecological sections—that in the Adirondack Foothills section (1.3) was more than twice that (0.6) in the Mohawk section—exemplifies the wide variance in the capacity of different areas to support beaver populations. Knowledge of these differences is necessary for sound management.

Nuisances caused by beaver are a problem in Fulton County. Prior to closure of the trapping season, there were four complaints in 1967 and five in 1968, or an average of 4.5 per year. Then in 1971 there were 15 complaints and in 1972 there were 43, associated with increases of 105 (1969-1971) and 44 (1971-1972) in the number of colonies. Thus the increased beaver population that followed the prohibition of trapping might be considered to have caused an additional 10.5 complaints in 1971 and 38.5 in 1972. As has been noted, the servicing cost per complaint was estimated at $77 in 1971 and $102 in 1972. On this basis, handling the additional complaints cost $808.50 and $3,927.00 in the two years, respectively, or $7.70 and $89.25 per added colony. On the other hand, based on the increase of $3,118.50 from 1971 to 1972 in the total cost of handling complaints, the cost per added colony in 1972 was $70.87. In relation to the total number of active colonies, the cost per colony was $7.73 in 1971 and $22.57 in 1972. Thus, in terms of beaver

damage, the cost per colony of maintaining 194 colonies was about three times that of maintaining 150 colonies. Maintenance of the latter population level, which represents occupancy of about 30 per cent of the potential sites, seems economically justified. However, there is need for more information concerning the value of beaver colonies in relation to the cost of servicing damage complaints.

Of the complaints recorded, 11 in 1971 and 25 in 1972 were from the Mohawk section. Thus, in this section, 20.0 per cent of the 55 colonies in 1971 and 36.2 per cent of the 77 colonies in 1972 were causes of complaints. In the Adirondack Foothills section, there were four complaints in 1971 and 18 in 1972, representing 4.2 per cent of 95 colonies and 15.6 per cent of 117 colonies, respectively. This is further evidence that the cost of maintaining high beaver populations is much greater in the Mohawk section of Fulton County than in the Adirondack Foothills section. In 1972 in the Mohawk section, the total cost of handling complaints ($2,550) represented $37 per colony. In both sections, the principal cause of complaints was plugged road culverts. If a practical means of making such culverts unattractive to beaver could be devised, the problem would be considerably reduced.

The substantial increase in beaver abundance in Fulton County following the prohibition of trapping in 1969, as recorded in this study, strongly indicates that trapping had been a major limiting factor. At the same time, the data indicate an occupancy of 30 to 40 per cent of the potential colony sites to be desirable and that trapping may be permitted under regulations designed to maintain the beaver population at that level.

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ROTENONE TOLERANCES OF STREAM-BOTTOM INSECTS[1]

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ABSTRACT

Stream-bottom insects varied greatly in their tolerance to rotenone. Tolerances did not adhere closely to taxonomic lines, but showed a possible relationship to oxygen requirements. The more sensitive genera tended to have short life cycles, high mobility and a potential for rapid repopulation. In many streams an exposure of 5 per cent emulsifiable rotenone formulation would eliminate undesired fish with only mild and temporary damage to the bottom fauna. Very few immature aquatic insects could survive a 48-hour exposure to 3 ppm of 5 per cent formulation.

Responsible resource management requires that any chemical treatment of natural waters be conducted in a way that will accomplish the desired ends with minimal damage to non-target biota. In the case of pesticide treatment of streams, there is an additional reason for minimizing damage to aquatic insect populations. It is highly probable that maximum benefits from such treatments could be obtained if they were made in the late summer and followed almost immediately by the stocking of fall fingerling game fish (trout or smallmouth bass). Benthic food production would then be funneled into the rapid growth of a single year class in a competition-free environment. This would, of course, not be practical if the fish toxicant had also eliminated most of the benthic insect fauna, even though repopulation might occur the next year. Binns (1967) and Swan (1965) found that prolonged treatment of streams with high rotenone concentrations effectively eliminated most aquatic insects and that, while some species became reestablished within a month or two, full restoration of the original fauna might require as long as 2 years.

In August and September of 1970, a segment of the Ten Mile River, a tributary of the Delaware River in Sullivan County (N.Y.), received three successive treatments with 5 per cent emulsifiable rotenone at concentrations of 1 ppm, 3.71 ppm and 4.75 ppm (6.0, 8.7 and 11.7 ppm-hours). A portion of the stream received only the 1 ppm treatment. On September 28, a series of nine bottom samples were obtained with a Surber square-foot bottom sampler at stations in parts of the stream that

[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project F-9-R located at the DeBruce Inland Fisheries Laboratory, Livingston Manor, N.Y. 12758.

Table 1. Summary of Aquatic Insects and Other Invertebrates in Bottom Samples Taken From the Ten Mile River, According to Degree of Rotenone Exposure, September 28, 1970*

Insect or other invertebrate	Rotenone exposure		
	None	1.0 ppm	1.0, 3.71 and 4.75 ppm
Ephemeroptera			
Baetidae§	5.0	13.7	4.0
Other families	0.3	0.0	0.0
Trichoptera			
Hydropsychidae	19.3	39.0	19.2
Other families	2.3	4.7	3.0
Diptera			
Chironomidae	9.7	6.3	7.0
Other families	0.0	0.3	0.0
Other insects	0.7	1.3	1.7
Total insects	37.3	64.4	34.9
Gastropoda	14.6	44.5	55.0
Oligochaeta	5.3	13.5	12.2
Total	57.2	122.6	67.2

* Values in animals per square foot (mean of three samples).
§ Predominantly *Paraleptophlebia.*

had had no treatment, only the 1 ppm treatment, and all three treatments. Analysis (Table 1) showed no significant differences between the three parts. The bottom fauna, dominated by hydropsychid caddisflies of the genera *Hydropsyche* and *Cheumatopsyche* and the mayfly *Paraleptophlebia* sp., had apparently not been affected to any appreciable extent. The total rotenone dosages applied to the Ten Mile River were considerably less than those reported by Binns (1967) for the Green River in Wyoming (65 ppm-hours to several times that dosage at downstream stations) and by Swan (1965) for Fall Creek in Oregon (over 48 ppm-hours of 2.5 per cent synergized formulation), suggesting that it might be possible to find a level of exposure that would kill undesired fish without seriously affecting the bottom fauna of most streams. To test this hypothesis, a series of experiments were conducted at the DeBruce laboratory in 1971, 1972 and 1973.

METHODS

Since the object of the experiments was to find tolerable levels of rotenone exposure for a wide variety of aquatic insects in the context of limited time and manpower, the methods used departed to a large extent from the standard canons of bioassay procedure as described by Doudoroff et al. (1951). Rather than determine exact LD_{50}'s for a few taxa,

a decision was made to study as wide a range of insects as was feasible and to estimate the exposure levels at which rotenone caused significant or total mortality.

In early tests, each experiment began with a series of similar bottom samples from a stream, usually Mongaup Creek, near the laboratory. Each sample was obtained by collecting the bottom fauna from 3 to 5 square feet of substrate with a Surber sample and a bottle brush. Samples were placed in 5-gallon glass jars partly filled with the stream water and taken to the laboratory where springwater was added to adjust the volume to 10 liters. The jars were then floated in a bath adjusted to 65° F. and aerated with compressed air via an air stone. A few small rocks were placed in the bottom of each jar for cover. Jars were held 24 hours before treatment. Treatment consisted of adding 5 per cent emulsifiable rotenone at 1 ppm or 3 ppm. At the end of 1, 3, 6, 16, 24 or 48 hours, 4 ppm of potassium permanganate ($KMnO_4$) were added to each jar to detoxify the rotenone. After 20 minutes the potassium permanganate was reduced with 6 ppm of sodium thiosulfate ($Na_2S_3O_2$), as would occur in a typical stream treatment (Engstrom-Heg, 1972). Jars were held an additional 24 hours and then removed from the bath. Most of the water was poured off through a Surber sampler, and the remainder, containing most of the insects, was poured out onto a large white enamel tray. The insects were removed from the tray and sampler and placed in one of two jars of 70 per cent alcohol for live and dead specimens, respectively. Each experiment included at least one control jar that was treated with potassium permanganate and sodium thiosulfate, but not with rotenone. At a later date insects from each jar were counted and identified, usually to genus, according to Pennak (1953) and Usinger (1956).

Later experiments were conducted in an identical fashion, except that individuals from a particular genus or group of genera, for which earlier tests had yielded insufficient information, were specifically collected and tested. Animals were collected from several Sullivan and Delaware County streams.

RESULTS

Typically, the control insects suffered an approximately 20 per cent mortality. This was to be expected in view of the stresses of collection and the fairly prolonged holding in an essentially abnormal situation with increased population density, reduced cover and no current. Mortality in the experimental insects began to depart significantly (chi-square at 5 per cent level with 1 d.f.) from that of the control insects at a wide range of exposures, varying from 1 ppm-hours (for *Baetis*) to over 144 ppm-hours (for *Cheumatopsyche*). Findings on individual taxa are listed in Table 2.

TABLE 2. SUMMARY OF RESULTS OF ROTENONE TOLERANCE TESTS ON AQUATIC INSECTS AND RELATED INFORMATION

Order	Family and genus	Number of animals		Exposure levels (in ppm-hours) according to degree of mortality			Survival (per cent)		
		Test	Control	Not significant	Significant*	Apparently total	Control	Non-significant level	Significant level*
Ephemeroptera	Baetidae								
	Baetis†	46	52	None	1, 3	6	80.8	..	4.9
	Ephemerella†	137	125	3, 6	9, 16, 48, 72	144‡	84.8	88.2	47.2
	Paraleptophlebia†	37	27	3, 6, 9, 16, 24	48, 72	144‡	85.1	86.7	9.5
	Heptageniidae								
	Stenonema	25	18	3, 6, 9	None	16‡	94.4	68.0	..
	Other (mixed)	10	29	3, 6	None	16‡	82.7	60.0	..
	Total†	35	47	3, 6, 9	None	16‡	86.6	65.7	..
Plecoptera	Pteronarcidae								
	Pteronarcys†	101	42	3, 6, 16, 24, 48	72	None	92.9	89.9	73.9
	Perlidae								
	Neophasganophora†	36	30	None	6, 9	16	76.7	..	38.9
	Perlodidate								
	Isogenus†	53	35	1	3	6, 9, 24	57.1	100.0	23.0
	Chloroperlidae								
	Chloroperlinae (mixed)†	97	17	3, 6	9, 16	48	76.5	58.3	20.0
Odonata	Aeschnidae								
	Aeschnia	10	10	3	None	None	100.0	100.0	..
Megaloptera	Corydalidae								
	Chauliodes†	46	30	3, 10, 16, 48	None	None	96.7	100.0	..
Tricoptera	Rhyacophilidae								
	Rhyacophila†	56	39	3, 6	9	16	61.5	73.3	14.3
	Glossosoma†	57	43	3, 6, 9, 16, 24, 48	None	72	58.1	55.6	..

	Philopotomidae	9	10	3, 9	None	None	50.0	55.6	..
	Psychomyiidae								
	Psychomyia	14	19	None	None	6‡, 9‡, 16, 58, 72	68.4	..	..
	Hydropsychidae								
	Hydropsyche†	116	79	3, 9, 48	6, 16, 24, 72, 144	None	69.6	69.2	28.9
	Cheumatopsyche†	19	13	3, 6, 9, 16, 24, 48, 72, 144	None	None	100.0	89.5	..
	Limnephilidae								
	Limnephilus†	80	19	3, 6, 9, 16	24	None	100.0	90.0	55.0
	Pycnopsyche†	50	30	3, 6	9, 16	24	100.0	100.0	70.0
	Brachycentridae								
	Brachycentrus†	213	222	None	1, 3, 6, 9	16, 24, 48, 72, 144	83.3	..	9.0
	Odontoceridae								
	Psilotreta	13	13	9, 24	None	None	92.3	69.2	..
Coleoptera	Elmidae								
	Limnius	6	2	9, 16, 48	None	None	100.0	83.4	..
Diptera	Tipulidae								
	Eriocera†	62	25	3, 6, 9, 16, 24	48	72	88.0	72.9	10.0
	Antocha	17	3	3, 6	None	9‡, 16, 24	100.0	50.0	..
	Simuliidae (mixed)†	449	92	1	3	6, 24	83.7	77.5	73.2
	Chironomidae								
	Pentaneura†	63	40	3, 6, 9, 16	24	None	92.3	75.5	42.9
	Other (mixed)	123	10	3	6, 9, 16	None	70.0	100.0	53.7
	Rhagionidae								
	Atherix	6	5	3, 16	None	48‡	80.0	33.3	..

Table 2. (*Continued*)

Order	Family and genus	Estimated rotenone tolerance	Life cycle	Mobility	Time to reestablish§
Ephemeroptera	Baetidae	Variable	Variable		
	Baetis†	Very low	Short	High	Short
	Ephemerella†	Intermediate to high‡‡	Intermediate	High	Intermediate
	Paraleptophlebia†	High	Intermediate	High	
	Heptageniidae	Intermediate to high			
	Stenonema	Intermediate to high		Intermediate	ND
	Other (mixed)	Intermediate to high		Intermediate	ND
	Total†	Intermediate to high		Intermediate	
Plecoptera	Pteronarcidae				
	Pteronarcys†	Very high	Long	High	Intermediate
	Perlidae				
	Neophasganophora†	Low		High	Intermediate
	Perlodidate				
	Isogenus†	Low		High	Intermediate
	Chloroperlidae				
	Chloroperlinae (mixed)†	Intermediate	Intermediate	High	ND
Odonata	Aeschnidae				
	Aeschnia	May be high	Long	Intermediate	ND
Megaloptera	Corydalidae				
	Chauliodes†	High	Long	High	ND
Tricoptera	Rhyacophilidae	Variable	Intermediate‡‡	Low	Long (?)
	Rhyacophila†	Low	Intermediate‡‡	Intermediate	ND
	Glossosoma†	High	Intermediate‡‡	Low	Long
	Philopotomidae	Intermediate	Intermediate‡‡	Low	ND
	Psychomyiidae				
	Psychomyia	Low	Intermediate‡‡	Low	ND

	Hydropsychidae	Very high	Intermediate‡‡	Low	Long
	Hydropsyche†	High	Intermediate‡‡	Low	Long
	Cheumatopsyche†	Very high	Intermediate‡‡	Low	Long
	Limnephilidae	Intermediate to high			
	Limnephilus†	High	Intermediate‡‡	Intermediate	ND
	Pycnopsyche†	Intermediate	Intermediate‡‡	Intermediate	ND
	Brachycentridae				
	Brachycentrus†	Very low	Intermediate‡‡	Intermediate	Intermediate
	Odontoceridae				
	Psilotreta	High	Intermediate‡‡	Intermediate	ND
Coleoptera	Elmidae				
	Limnius	High	Long (?)	High	ND
Diptera	Tipulidae	Variable			
	Eriocera†	High	(?)	Low	Long
	Antocha	Low to intermediate	(?)	Low	Long
	Simuliidae (mixed)†	Low	Short	Intermediate	Short
	Chironomidae				
	Pentaneura†	Intermediate	Short	Intermediate	Short
	Other (mixed)	Intermediate	Short	Intermediate	Short
	Rhagionidae				
	Atherix	Intermediate	Short (?)	Low	Short

* Significantly different from mortality of controls, based on chi-square (adjusted values) at 5 per cent level of confidence with 1 degree of freedom.

§ After Binns (1967); ND indicates he gave no data on time to reestablish.

† Included in Figure 1.

‡ Based on total mortality to small, statistically insignificant number of insects. These taxa may be more tolerant than indicated.

†† The genus *Ephemerella* includes a number of species with different ecological adaptations and, quite possibly, with a considerable range of rotenone tolerances. At least three species were included in the tests.

‡‡ Life cycles of caddisflies tend to vary greatly with food and other habitat conditions. Many species ordinarily produce one or two broods per year.

Use of ppm-hours as a unit of exposure is based on the approximately hyperbolic character of most concentration-response curves. The product of toxicant concentration and response time is often nearly constant through a fairly wide range of values. It should be recognized, however, that this relationship is merely approximate and that it may be invalidated by threshold effects at very high or low concentrations (Burdick, 1957). The data indicate that its use was justified for this set of experiments, in that mortality generally increased with increased exposure in ppm-hours, whether the toxicant was added to 1ppm or 3 ppm.

The estimated tolerances should probably be regarded as minimal, in that the experiments were run on stressed animals uprooted from microhabitats that in many cases may be quite exacting. It is likely that most of the insects would have tolerated somewhat greater exposures in their natural stream setting.

Further analysis of the data (Figure 1) indicates a rather sharp increase in the number of affected genera at approximately the 10-ppm-hour level. Interestingly, the three dominant genera in the Ten Mile River fauna turned out to be highly resistant. It can be seen that the insects of the orders Ephemeroptera, Plecoptera and Diptera are highly variable in their tolerance to rotenone and that strong differences within a single family are not unusual. Limited information, including fragmentary data not listed in Table 2 as well as scattered references in the literature (Claffey and Ruck, 1967; Zischkale, 1952; Leonard, 1939), suggests that members of the orders Odonata, Megaloptera and Coleoptera and burrowing mayflies of the family Ephemeridae may all be quite resistant. Binns (1967) found that adult air-breathing aquatic insects successfully withstood prolonged rotenone exposures that killed most immature forms. Observations on the few adult coleopterans and hemipterans in the present samples tend to confirm this finding. Observations on non-insect benthos indicate that turbellarian worms are very sensitive to rotenone and that the aquatic isopod *Asellus militaris* ranks with the more resistant insects.

DISCUSSION

In fish, rotenone tolerance tends to vary inversely with exygen requirements, as would be expected for a respiratory poison. A similar pattern may hold for immature aquatic insects. Roback (1962) found that the rotenone-resistant caddisfly genera *Hydropsyche* and *Cheumatopsyche*, while occurring in a wide range of habitats, were tolerant of polluted waters with high BOD levels. The work of Degan (1973), as reviewed by Schnick (1974), suggests that antimycin, which has a mode of action similar to that of rotenone, may have similar effects on aquatic insects. Populations of *Baetis*, *Brachycentrus* and *Antocha*, all rotenone-sensitive genera, were eliminated or drastically reduced after treatment of a stream

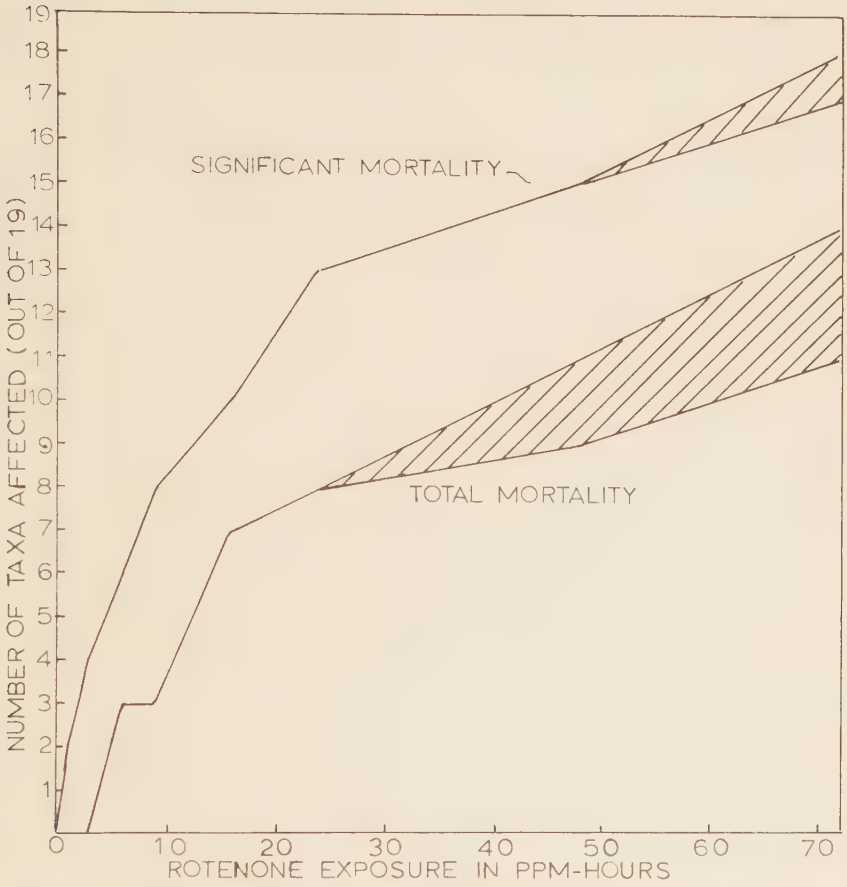

Figure 1. Number of insect taxa suffering significant (chi-square at 5 per cent level with 1 d.f.) or total mortality at various rotenone exposures. Shaded areas represent range between maximum and minimum estimates resulting from missing or inadequate tests at high concentrations. Only those taxa (19 as noted in Table 2) for which 30 or more insects were tested are included.

with 10 to 40 ppb of the chemical. The abundance of *Hydropsyche* was less severely depressed, and the elmid beetle *Stenelmis* was apparently not affected.

Rotenone treatment of a stream to eliminate rough fish generally requires application of at least 6 ppm-hours of 5 per cent rotenone formulation, even for relatively short segments (Engstrom-Heg and Loeb, 1971). Lennon and Parker (1959) found that a dose of 10 ppm-hours, introduced as 5 ppm for 1 hour, followed by 1 ppm for 5 hours, effectively killed carp. Calculations based on measurement of stretch-out in pool-and-riffle streams indicate that a slightly modified version of this

pattern, in which introduction began and ended with 30-minute bolts at 5 ppm, would effectively treat a stream segment several miles long without undesirable attenuation.

The bioassay results show that there is no level of application at which rough fish can be eliminated without at least minor damage to the bottom fauna. However, it is possible to minimize damage by avoiding excessively prolonged or concentrated treatment. Fortunately, there is a strong tendency for the more sensitive insects to be highly mobile and/or to have short life cycles, and thus to repopulate depleted areas rapidly through drift, migration and oviposition (Table 3). It is probable that

Table 3. Relationship of Rotenone Tolerance to Rate of Recolonization For Various Aquatic Insects

Rotenone tolerance	Rate of recolonization*		
	Rapid§	Intermediate	Slow†
Low (significant at 1 or 3 ppm-hours)	*Baetis* Simuliidae	Perlodidae Brachycentridae	..
Intermediate (significant at 6, 9 or 16 ppm-hours)	Chironomidae Rhagionidae	*Ephemerella* Heptageniidae Perlidae *Antocha*	..
High (significant at 24 or more ppm-hours)	..	*Paraleptophlebia* *Pteronarcys* Elmidae	*Glossosoma* Hydropsychidae *Eriocera* *Chauliodes*

* After Binns (1967).

§ Recolonization occurred at three or more stations within 2 months.

† Still absent at three or more stations at 1 year, or requiring 2 years at any station.

in most streams, treatment at 10 ppm-hours would result in mild and temporary damage. This, however, should not be taken as a hard-and-fast dictum. For instance, in the late summer in 1971 and 1972, the bottom fauna of Mongaup Creek was dominated by rotenone-sensitive caddisfly larvae of the genus *Brachycentrus*, which probably would have been eliminated by treatment at this level. Streams should be evaluated individually, and estimates of probable damage to the bottom fauna should be considered in planning any extensive rotenone treatments. If animals not listed in this paper should be important as fish forage, it would not be difficult in most cases to determine their approximate rotenone tolerance.

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DETERMINING THE SEX OF FISHER FROM THE LOWER CANINE TEETH[1]

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ABSTRACT

Data for 247 fall-trapped fisher of known sex indicate that sex can be determined from the size of the lower canine teeth. Maximum root width was found to be the best index, with 99.3 per cent of 149 females and 100 per cent of 98 males being classified correctly. The value of this technique lies in the fact that reliable data on the sex composition of a population can be obtained without collecting complete carcasses.

In 1975 an investigation was undertaken of the distribution and population dynamics of the fisher (*Martes pennanti*) in northern New York. Information was obtained from fisher carcasses collected from cooperating trappers plus a few road-killed and diseased specimens. It soon became apparent that, if a simple and accurate technique could be developed for sexing fisher without requiring the entire carcass, a larger sample could be obtained at much less cost. Use of such a technique would enable trappers to save the lower jaw only for examination and keep the rest of the carcass for bait, an important consideration in maintaining their cooperation. Therefore, a study was made to determine if canine teeth could be used to determine the sex of fisher in a manner similar to that described by Sauer (1966).

PROCEDURE

Fisher carcasses were collected during the 1975 trapping season (October 25-December 31) and were sexed anatomically. For most of the specimens, the lower canine tooth was extracted by boiling the head for approximately 1 hour and then removing the tooth with dental pliers. In a few cases, teeth were removed by using various tools without boiling the skull. The total sample of 247 comprised teeth from 98 male and 149 female fisher of unknown ages.

Measurements of maximum root width and maximum root thickness (Figure 1) were taken to the nearest 0.1 millimeter with a caliper rule.

[1]A contribution of Federal Aid in Fish and Wildlife Restoration Projects W-130-D, W-135-D and W-136-D. The authors wish to thank wildlife staffs of Regions 4, 5 and 6 for help in collecting biological material and Dr. George Mattfeld of the Adirondack Ecological Center of Syracuse University for review and statistical analysis. Special thanks are extended to the many trappers involved in the study.

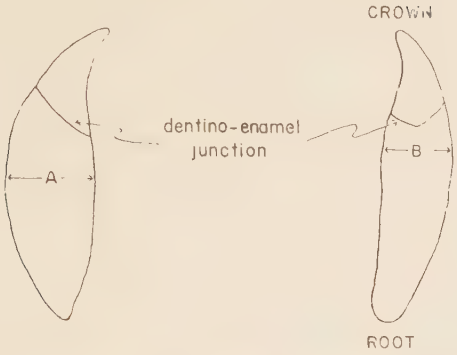

Figure 1. Measurements made of lower canine teeth of fisher: A—maximum root width; B—maximum root thickness.

According to Sauer (1966) these two dimensions reliably separate black bears by sex. The mean, range and standard deviation from the mean for the two measurements were computed for each sex, and the results were compared for significant differences.

FINDINGS

Extraction of the canine teeth was found to be easier when the skull had been boiled. This method prevented damage to the teeth.

The measurements recorded are summarized in Table 1. For both measurements, the mean for males was greater than that for females. When plotted, the measurements for each sex were found to form a normal distribution. With respect to root width there was no overlap between the sexes, but an overlap did exist in the data for root thickness.

Since no overlap between the sexes occurred in the data for root width, a dividing point was determined that would allow all the teeth

TABLE 1. SUMMARY OF MEASUREMENTS OF CANINE TEETH FROM FISHER OF KNOWN SEX TAKEN DURING THE FALL IN NORTHERN NEW YORK

Item	Male	Female
Number of specimens	98	149
Maximum root width*		
Mean	6.44	4.85
Standard deviation	0.300	0.298
Range	5.9-7.0	3.4-5.7
Maximum root thickness*		
Mean	4.80	3.58
Standard deviation	0.432	0.262
Range	3.4-6.0	3.0-4.7

* Data in millimeters.

measured to be assigned to one sex or the other. Using 2.6 standard deviations ($P=0.995$) from the mean in both sexes, a maximum root width of 5.6 millimeters was derived as the dividing point. Any specimen having a measurement of 5.64 (read as 5.6) millimeters or less was classed as a female, and any specimen having a measurement of 5.65 (read as 5.7) millimeters or more was classed as a male. Applying this criterion to the sample it was found that 148 of 149 females and all 98 males were sexed correctly. The one female incorrectly sexed had a maximum root width of 5.7 millimeters which was just over the 5.6-millimeter limit.

The same approach was applied to the data for root thickness and, using 1.7 standard deviations ($P=0.955$) from the mean in both sexes, a maximum root thickness of 4.0 millimeters was derived as the dividing point. Any specimen having a measurement of 4.04 (read as 4.0) millimeters or less was classed as a female, and any specimen having a measurement of 4.05 (read as 4.1) millimeters or more was classed as a male. When this criterion was applied to the sample it was found that 147 of 149 females and 94 of 98 males were sexed correctly. The two females which were sexed incorrectly had maximum root thicknesses of 4.4 and 4.7 millimeters, both well within the range for males. The four males which were sexed incorrectly had measurements of 3.4, 3.6, 4.0 and 4.0, two of which were well within the range for females. The female which was sexed incorrectly by maximum root width was also sexed incorrectly by maximum root thickness.

DISCUSSION

So far as the authors are aware, sexual dimorphism in the dentition of fisher has not been reported in the literature. The findings of the present study indicate that measurements of maximum root width or maximum root thickness of the canine teeth may be used satisfactorily for sexing fisher. The root-width dimension appears to have a greater degree of accuracy. A gauge machined to accept a tooth root 5.64 millimeters wide would serve to separate the sexes, a tooth that would fit into the gauge would be considered as being from a female, while one that would not fit the gauge would be considered as being from a male.

All the specimens measured had been trapped during the fall in an 18,000-square-mile area in northern New York. The differences noted in the two dimensions of the canine teeth of these fisher may or may not hold true for other geographic regions.

LITERATURE CITED

Sauer, Peggy R. 1966. Determining sex of black bears from the size of the lower canine tooth. N.Y. Fish and Game Jour. 13(2):140-145.

BLACK SEA BASS IN NEW YORK WATERS[1]

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ABSTRACT

Black sea bass were found to be slow growing, reach an average total length of only 378 millimeters at annulus IX. The ratio of males to females did not differ significantly from 1:1. Larger fish were mostly males. Migration southward from New York waters appears to begin in October. Local fish winter at least as far south as off the Delaware coast. Northward migration back to New York waters apparently begins in late April and early May. To assure that black sea bass reach sexual maturity and spawn at least once, it would be necessary to raise to at least 9½ inches the minimum size for fish that may be bought or sold and apply it to sport-caught fish as well as those traded in commerce.

Commercial and sport catches of black sea bass (*Centropristis striata*) in New York waters have declined in recent years. McHugh (1972) documented the rise and fall of commercial landings at New York ports. Landings were relatively stable at around 225 metric tons a year from the turn of the century through 1943. This was followed by a sharp increase to a record 1,270 metric tons in 1951. A decline followed and, by 1970, only about 32 metric tons were landed. Briggs (1968) reported a decline in the sport catch in the waters of eastern Long Island from about 198,000 fish in 1964 to only 24,000 in 1966. These declines, plus a general lack of knowledge of the species, led to the inclusion of a study of aspects of the life history of black sea bass as a part of a general study of artificial reefs and the fishes they attract in New York waters.

Kismet and Fire Island reefs were chosen as study areas. They were described in detail by Briggs (1975). Briefly, Kismet reef lies in about 6 meters of water in Great South Bay, while Fire Island reef lies in about 21 meters of water in the Atlantic Ocean (Figure 1).

METHODS

Black sea bass were caught in fish pots set at the reefs from May through November from 1969 to 1972. The pots and the method of fishing them were described by Briggs (1975). Nearly all the black sea bass caught were sexed by external examination using the criteria noted by Lavenda (1949).

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[1]Contribution No. 78-2 of the Division of Marine Resources. The author thanks Dr. Frank J. Schwartz of the Institute of Marine Science at the University of North Carolina and Fred Lux of the National Marine Fisheries Service at Woods Hole, Massachusetts, for the use of their specimens of black sea bass. Frederick M. Mushacke of the New York State Department of Environmental Conservation prepared the illustrations. This research was funded in part by Federal Aid in Fish and Wildlife Restoration Project F-15-R.

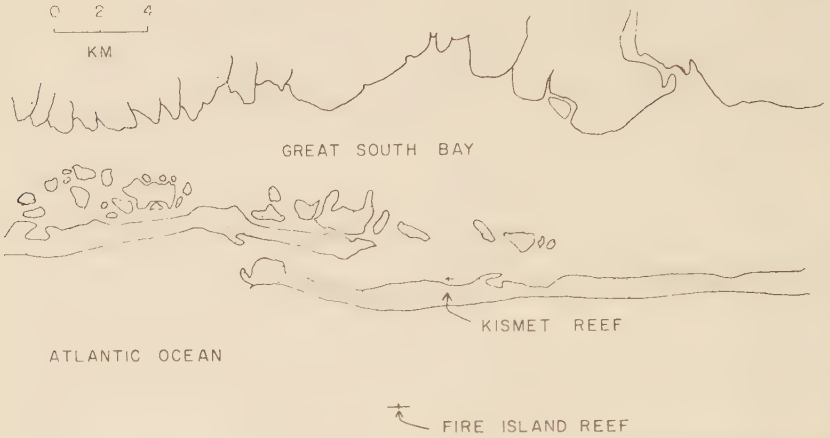

Figure 1. Map of study area showing location of Kismet and Fire Island artificial reefs.

Table 1. Number of Black Sea Bass Tagged and Types of Tags Used

Type of tag	1969	1970	1971	1972	Total
Kismet reef					
Floy anchor tag	6	0	1	4	11
Petersen disc	4	3	1	0	8
Total	10	3	2	4	19
Fire Island reef					
Floy anchor tag	54	27	15	97	193
Petersen disc	28	24	27	0	79
Total	82	51	42	97	272

> "The female is sleeker and more graceful, with a more pointed snout than the male, and has a narrower caudal peduncle in relation to general body outline . . . In males over 25 cm. standard length an adipose occipital hump is formed . . . as early as February . . . and there is still some evidence of it as late as September. In females this structure is absent . . ."
>
> "Differences in sexual coloration develop with the onset of maturity, becoming more pronounced with increase in age. The large males at spawning time are bright blue, especially around the eyes and the adipose hump . . . A tinge of this bright blue can be observed even in the winter. The females . . . darker and duller blue. In July the females are more brownish in color. Some are almost completely white . . ."

All the bass caught were measured to the nearest 5 millimeters in total length, and 291 were tagged. Table 1 presents the number tagged at each site and the types of tags used. Of those caught at Fire Island reef, 304 were weighed to the nearest 25 grams, and the data were used to calculate length-weight relationships.

Scale samples were removed from 359 fish (including 27 from the area off New England and in the mid-Atlantic Bight, i.e., from Cape Cod to Cape Hatteras[2] and nine specimens of known age received from North Carolina). Impressions of these scales were made in clear plastic and were read at 40X magnification on a scale projector. Lavenda's (1949) criteria for an annulus were used.

> "An annulus in the sea bass is formed by the bunching of the line configurations or circuli, forming a dark band about the scale. As the fish grows older and is laying down these annual year marks, there is a tendency for the annuli formed in the first and second years to become indistinct. These faint configurations were definitely ascertained as true annuli by the study of the scales of one- and two-year-old fish."

After discarding regenerated and unreadable scales and those that gave differing ages upon two readings, scales from 253 fish were used for age and growth determination. Also, 85 young-of-the-year black sea bass collected at Woods Hole, Mass., in October 1961 were measured and used to confirm the first annulus.

RESULTS

Growth in relation to age and sexual maturity was of primary interest. Data on catch rates, sex ratios and migratory movement were also analyzed.

Catch Rate

Although 509 black sea bass were caught at Fire Island reef, catch rates were low (Table 2). The best catches were made in the summer.

Table 2. Catch Rates for Black Sea Bass Caught at Fire Island Reef

Catch rate	May	June	July	Aug.	Sept.	Oct.	Nov.
Number caught	7	63	113	168	88	68	2
Number per pot per haul	0.07	0.24	0.71	1.05	0.73	0.38	0.03

Too few (30) were caught at Kismet reef to indicate meaningful catch rates in so far as seasonal occurrence is concerned.

Sex Ratio

Of the 509 fish caught at Fire Island reef, 502 were sexed, 240 being male and 262 female. Chi-square analysis ($\chi^2 = 0.2868$) revealed that this was not significantly different from a 1:1 ratio. Sex could not be deter-

[2] Taken during a cruise of the research vessel Albatross IV of the National Marine Fisheries Service, operating out of Woods Hole, Mass., in the fall of 1969.

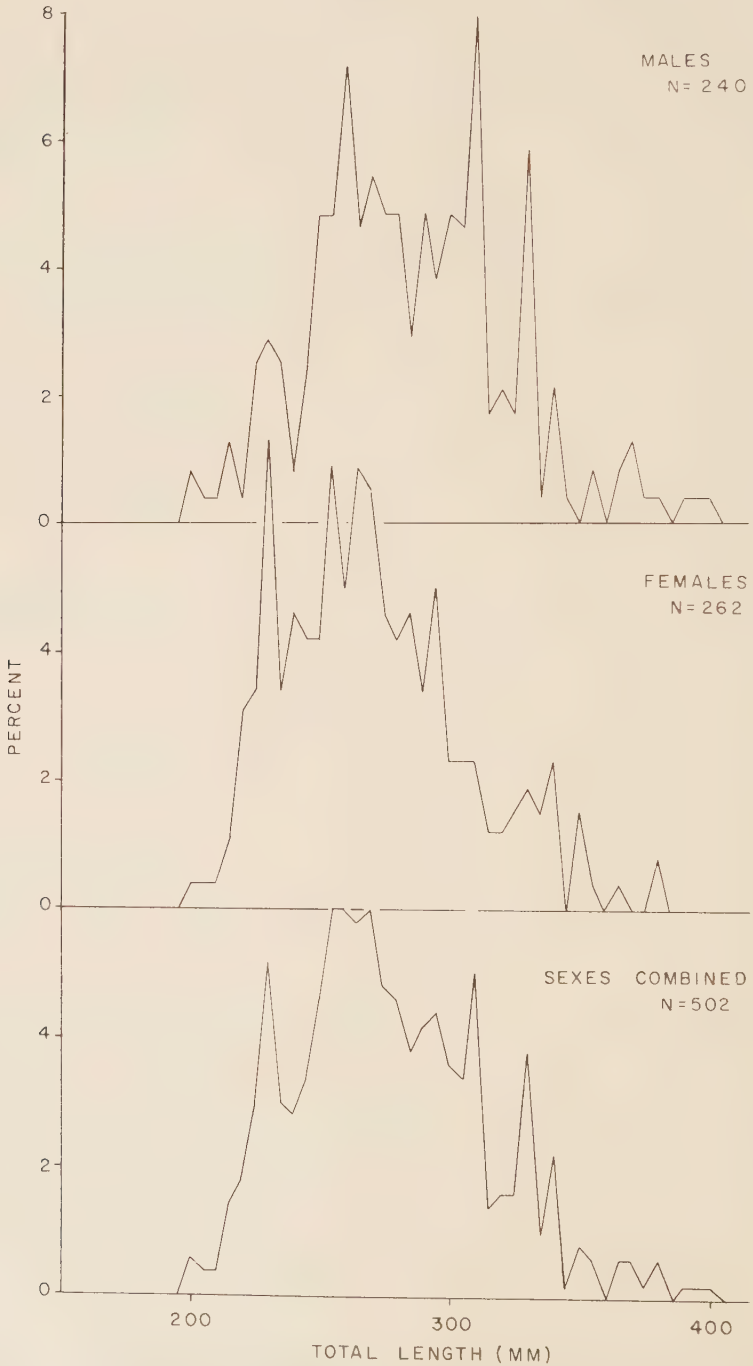

Figure 2. Length-frequency distribution for black sea bass caught at Fire Island reef.

mined by external examination of specimens less than 190 millimeters in total length.

Size

Length frequencies for 240 male and 262 female black sea bass caught at Fire Island reef are shown in Figure 2. Males ranged from 200 to 400 millimeters long and averaged 285, while females ranged from 200 to 380 millimeters long and averaged 270 (Table 3). There was little variation

Table 3. Size of Black Sea Bass Caught At Fire Island Reef

Size*	May	June	July	Aug.	Sept.	Oct.	Nov.	Season
				Male				
Range	200-370	200-370	210-380	225-380	225-340	235-400	315	200-400
Mean	289	275	285	276	297	296	315	285
				Female				
Range	245-330	200-350	215-380	200-380	225-350	230-340	255	200-380
Mean	295	262	274	264	278	283	255	270

* Total length in millimeters.

in mean length through the season, other than a gradual increase in the fall indicative of normal growth of individuals in the population. Males generally averaged larger than females, most (65 per cent) of the fish more than 295 millimeters long being males.

Since only 30 balck sea bass were caught at Kismet reef, measurements were not separated by sex (although those that could be were sexed). These fish ranged from 160 to 395 millimeters long and averaged 266. Specimens under 200 millimeters long were found only at this site, six (20 per cent) of the bass caught there being in that category.

Length-weight Relationship

Length-weight relationships for 157 male and 147 female black sea bass caught at Fire Island reef were calculated using the methods of least squares. The resultant equations were

$$\text{Males:} \quad \log W = -4.8021 + 3.0197 \log L$$
$$\text{Females:} \quad \log W = -5.1557 + 3.1728 \log L$$

These regressions were subjected to a "t" test and were found to be not significantly different at the 0.05 level ($t = 1.8271$). Therefore, the length-weight relationship for the 304 fish of both sexes was calculated, and the following equation was derived

$$\log W = -5.0291 + 3.1155 \log L$$

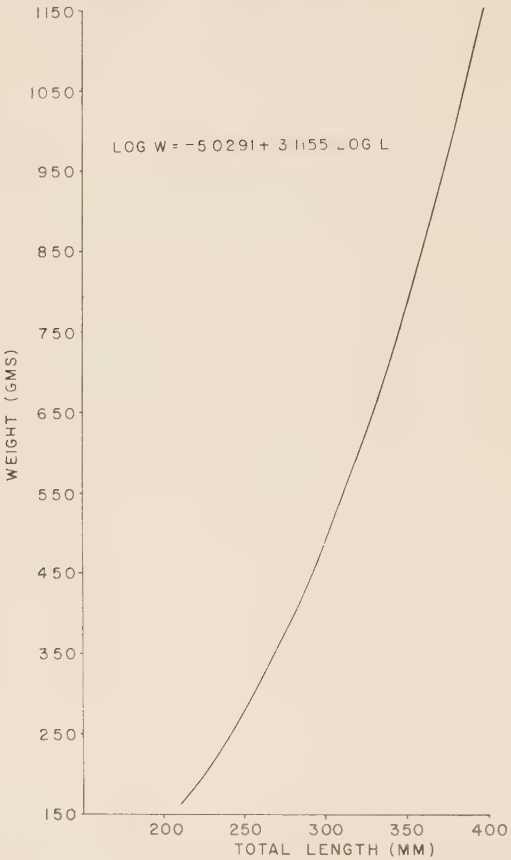

Figure 3. Length-weight relationship for black sea bass caught at Fire Island reef.

Table 4. Calculated and Observed Average Weights of Black Sea Bass According to Length

Total length (millimeters)	Weight (grams)	
	Calculated	Observed average
210*	161	125
225	199	194
250	276	262
275	372	378
300	488	486
325	626	640
350	789	825
375	978	925
395*	1150	1125

* Smallest and largest specimens weighed and measured.

This relationship is shown graphically in Figure 3. Comparisons of calculated and observed average weights (Table 4) showed close agreement.

Age and Growth

Since most of the bass collected were adult fish of various ages, determination of their growth rates required back-calculation based on annulus identification.

Annulus Formation While Lavenda (1949) gave criteria for identifying an annulus on scales of the black sea bass, he did not determine when it was formed. He assumed it was formed in winter. In the present study, the small sample size (only 253 readable scales) and a scarcity of specimens in age groups 0 and I made determination of the validity and time of annulus formation difficult. There is indication (Table 5) from the measurements of the distance from the last annulus

Table 5. Avegage Distance (millimeters × 40) From Last Annulus to Anterior Edge of Scale For Black Sea Bass of Age Groups II and III*

Year	May	June	July	Aug.	Sept.	Oct.	Nov.
			Age group II				
1969	36 (1)	46 (1)	19 (12)	16 (8)	15 (3)	33 (1)	37 (6)
1970	..	44 (8)	20 (8)	22 (2)	..	42 (2)	..
			Age group III				
1969	26 (1)	..	12 (10)	14 (20)	19 (13)	34 (1)	..
1970	..	23 (8)	19 (11)	18 (18)	12 (3)	33 (2)	..

* Figures in parentheses represent number of scale samples.

to the anterior edge of the scale that the annulus begins to form in July. This held for age groups II and III in 1969 and 1970. Since this involved three year classes (1966, 1967 and 1968), one of which (the 1967 year class) was sampled in both years, and the time of annulus formation occurred at the same time of year, the author accepts the annulus as being formed in July and as being a true annulus. Nevertheless, he recognizes that the data are scanty and realizes the limitations forced upon his assumptions by the small sample size.

Confirmation of the first annulus cannot be treated at this point because the lack of bass in age groups 0 and I from the reefs necessitated that the first annulus be confirmed by comparing back-calculated lengths of older specimens with the length of juveniles from other sources. This comparison is presented later under a subsequent topic.

Fish Length-Scale Length Relationship The fish length-scale length relationship must be calculated before the length at time of

annulus formation can be determined for older fish. Lagler (1952) gave the equation

$$L = a + bS$$

where:

L = body length
a = a constant (to be derived from the relevant data)
b = a constant (to be derived from the relevant data)
S = scale length (corresponding to body length above)

This equation may be solved by using the method of least squares, the general linear function, where:

$$X_1 = a + bX_2$$

by substituting X_1 for L and X_2 for S, the resultant equation derived from the data for the 253 specimens with readable scales being

$$X_1 = -4.1778 + 1.1873X_2$$

The relationship of fish length to scale length is shown graphically in Figure 4. A correlation coefficient (r_{12}) of 0.9218 was obtained, indicating

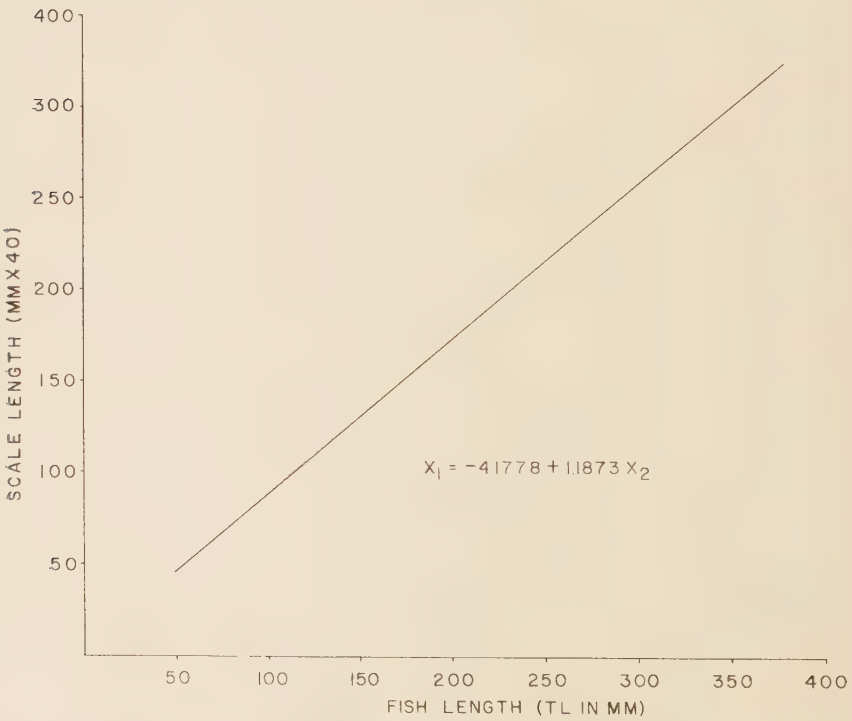

Figure 4. Fish length-scale length relationship for black sea bass.

Table 6. Analysis of Variance For Linear Regression of Fish Length-Scale Length Relationship For 253 Black Sea Bass

Source of variation	Degrees of freedom	Sum of squares	Mean square	*F*	
				Value	Correlation
Total	252	453,337.72			
Regression	1	385,223.71	385,223.71	1,419.55	6.76**
Deviation	251	68,114.01	271.37		

** Highly significant at 0.01 level of probability.

a close relationship between the two variables. Analysis of variance (Table 6) indicates that the relationship did not differ significantly from linearity and is best described by the straight-line function.

Back Calculation Using the equation given by Lagler (1952)

$$L_1 = \frac{S_1\ (L_2 - a)}{S_2} + a$$

where:

L_1 = length of fish at any annulus
S_1 = length of scale at any corresponding annulus
L_2 = length of fish at capture
S_2 = length of scale at capture
a = a constant (e.g., −4.1778 as determined previously in this case)

back-calculations of fish length at previous ages for 247 black sea bass of age group I or older were made (Table 7). Growth was generally slow, comparable to similar rates found by Cooper (1967) for tautog (*Tautoga onitis*) and by Finkelstein (1969) for scup (*Stenotomus chrysops*). Black sea bass (sexes combined) averaged only 91 millimeters in total length at annulus I, 193 at annulus II, 240 at annulus III, 276 at annulus IV, 301 at annulus V, 319 at annulus VI, 341 at annulus VII, 367 at annulus VIII and 378 at annulus IX. No fish older than 9 years were captured in this study, although the species may live as long as 20 years (Lavenda, 1949).

Confirmation of First Annulus Scales from six age 0 fish were examined. These fish were all caught in November by National Marine Fisheries Service personnel. They ranged from 50 to 80 millimeters in total length and averaged 70. An additional 85 of the same age, collected at Woods Hole, Mass., in October 1961, ranged from 35 to 55 millimeters long and averaged 45. The sizes of these young-of-the year bass correlated well (providing for some growth to the next July) with the range of back-calculated lengths at annulus I. This correlation confirmed the determination of annulus I.

Table 7. Frequency Distribution of Back-calculated Lengths At Previous Annuli For 247 Black Sea Bass

Fork length (millimeters)	Annulus and sex																	
	I			II		III		IV		V		VI		VII		VIII		IX*
	§	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
40- 49	..	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
50- 59	..	5	10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
60- 69	1	14	14	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
70- 79	1	12	26	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
80- 89	1	19	20	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
90- 99	3	17	15	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
100-109	1	7	14	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
110-119	2	13	11	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
120-129	..	11	7	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..
130-139	1	3	7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
140-149	..	5	1	3	6	..	..	..	..	..	..	..	..	..	..	..	..	..
150-159	..	2	..	7	8	..	..	..	..	..	..	..	..	..	..	..	..	..
160-169	..	..	..	12	10	..	..	..	..	..	..	..	..	..	..	..	..	..
170-179	..	..	..	8	17	..	..	..	..	..	..	..	..	..	..	..	..	..
180-189	..	..	..	16	16	..	..	..	..	..	..	..	..	..	..	..	..	..
190-199	..	..	..	19	17	..	6	..	..	..	..	..	..	..	..	..	..	..
200-209	..	..	..	21	21	4	1	..	..	..	..	..	..	..	..	..	..	..
210-219	..	..	..	5	11	9	11	..	..	..	..	..	..	..	..	..	..	..
220-229	..	..	..	13	8	7	14	..	..	..	..	..	..	..	..	..	..	..
230-239	..	..	..	5	7	20	16	..	..	..	..	..	..	..	..	..	..	..
240-249	..	..	..	..	1	17	21	3	3	..	..	..	..	..	..	..	..	..
250-259	..	..	..	1	..	20	11	5	2	..	..	..	..	..	..	..	..	..
260-269	..	..	..	..	..	11	8	7	7	..	1	..	..	..	..	..	..	..
270-279	..	..	..	..	..	5	1	14	6	..	1	..	..	..	..	..	..	..
280-289	..	..	..	..	..	1	..	6	11	3	1	..	..	..	..	..	..	..
290-299	..	..	..	..	..	..	1	9	5	8	3	..	1	..	..	..	..	..
300-309	..	..	..	..	..	..	..	4	..	6	3	4	1	..	1	..	..	..
310-319	..	..	..	..	..	..	..	..	..	1	4	3	..	..	..	..	..	..
320-329	..	..	..	..	..	..	..	..	1	3	1	1	2	2	1	..	..	..
330-339	..	..	..	..	..	..	..	..	..	1	2	1	1	1	..	..	..	..
340-349	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	..

350-359	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1	1	..	..
360-369	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1	1	..	..
370-379	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	2	1
Total	10	112	125	111	123	94	90	48	35	22	16	10	6	5	5	2	2	1
Mean length																		
Each sex	§	94	89	191	194	243	236	277	276	303	298	318	322	343	339	359	376	378
Both sexes	97	91		193		240		276		301		319		341		367		*
Increment																		
Each sex	§	94	89	97	105	52	42	34	40	26	22	15	24	25	17	16	37	19
Both sexes	97	91		102		47		36		25		18		22		26		11

* No female of this age was taken.

§ Immature fish whose sex could not be determined.

Tagging

Only three tag returns were received from bass tagged at Kismet reef. All were from fish caught by anglers at that site from 2 days to 3 months after the time of release. For the bass tagged at Fire Island reef, 19 tag returns were received, 14 from anglers fishing New York waters and three from anglers fishing to the south of New York. Commercial pot fishermen (one from New York waters and one from southward) sent in the other two tags received.

McHugh (1972) reported that, for the Atlantic coast as a whole, anglers exploited black sea bass to a greater degree than did commercial fishermen, although he did not state that this held true for New York waters. The tagging results from the present study indicate that anglers in New York waters do harvest more black sea bass than does the commercial fishery. This is further evidenced by the fact that the intensive pot fishery for lobsters at Fire Island reef (Briggs and Zawacki, 1974) apparently caught no tagged fish, while the light sport fishery there (Briggs, 1975) caught at least 10 tagged fish.

Six black sea bass that were tagged at Fire Island reef were recaptured in project gear at that site between 4 and 77 days after they were released. Of the other 21 tag returns received, 12 were from fish taken by anglers at the tagging sites the same year as released. Two fish moved into Great South Bay and were caught by anglers there within 3 months after being tagged at Fire Island reef. One fish tagged August 28, 1970 at Fire Island reef was caught the following November 1 in 36 meters of water about 32-40 kilometers east of Manasquan Inlet, New Jersey.

Six black sea bass tagged at Fire Island reef were caught the year after they were tagged. Four of these were taken in New York waters: one at the tagging site; one in a lobster pot off East Quogue (about 48 kilometers east of Fire Island reef) in 21-24 meters of water; one "near Montauk Point"; and one "off City Island" in western Long Island Sound near New York City. Two fish tagged in 1972 were caught the following spring far south of the tagging site: one by a commercial fisherman on April 30 about 13 kilometers east of Indian River, Delaware; and one by an angler on May 16 "off Cape May, New Jersey".

DISCUSSION

The somewhat larger average size of males and the preponderance of that sex in black sea bass over 295 millimeters long was not unexpected, since Lavenda (1949) had shown that protogyny is exhibited by the species. Examination of his Figure 1 indicated that he found no females in New York waters larger than 350 millimeters in standard length. Indeed, off Cape May, New Jersey, sex reversal apparently started with smaller females, as he found none of that sex over 300 millimeters long.

That larger females (up to 380 millimeters in total length) were caught at Fire Island reef during the present study may be explained by the two different measurements used, i.e., standard length vs. total length. In general, the size range of females at Fire Island reef from 1969 through 1972 was essentially the same as that which Lavenda (1949) found for New York waters in 1945. However, he did find more large males than were found in the present study.

Although not many tags were returned, the data from them indicate that black sea bass move little in the summer once they have become established at a site. At least one fish returned to the tagging site the following year. It appears that southern migration may begin in October and that local fish may start returning north during late April and early May. The distribution of catch rates tends to support the data from tag returns in regard to time of migration.

Whether black sea bass found off Long Island in the summer spend the winter farther south along the coast than off Delaware is not known. Likewise, the contribution of black sea bass that summer in New York waters to the winter trap fishery off the Carolinas, if any, is unknown. Additional tagging, either off New York in the summer or off the Carolinas in the winter, would be helpful in better delineating the migration patterns of the species. Also, additional tagging studies could provide data on mortality and survival rates which would aid in developing a management plan for black sea bass.

At present, the only management imposed on black sea bass fisheries in New York waters is an 8-inch (200-millimeter) minimum size for fish that may be bought or sold. Such fish would fall near the average size for age group II (193 millimeters). Sex could not be determined by external examination for specimens less than 190 millimeters long which also is near the average size for age group II. It would appear, then, that black sea bass are not sexually mature until they are at least III+ years old. The average length at annulus III is 240 millimeters (approximately 9½ inches). To assure that black sea bass reach sexual maturity and, presumably, have a chance to spawn at least once, it would be necessary to raise to at least 9½ inches the minimum size for fish that may be bought or sold. If this were done, this size limit should also apply to sport-caught fish as well as those traded in commerce, for, on the basis of tag returns, the sport fishery may harvest more black sea bass in New York waters than does the commercial fishery.

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TWO ANOMALIES OF FISH LARVAL TRANSPORT AND THEIR IMPORTANCE IN ENVIRONMENTAL ASSESSMENT[1]

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ABSTRACT

Environmental impact assessments for industrial plants using water generally include estimates of ichthyoplankton entrainment. The pattern of transport of fish larvae in water currents determines the proportion of a population which will pass through the zone of intake influence and the proportion of those passing the intake which will be entrained. Sampling studies revealed two anomalies of importance to such estimates: (1) data from field surveys in the Hudson River estuary showed that larvae are not transported in the water mass like solute particles; and (2) data from entrainment monitoring at generating plants on the Great Lakes showed that larval densities in the entrained water are not always the same as those in the surrounding ambient water. Realistic assessment of entrainment impact is both environmentally and economically important, and laboratory observation of the conditions that determine patterns of larval transport would be desirable.

Environmental impact assessments for industrial installations which pump from natural waterbodies generally include the predicted effects on fish populations of the withdrawal of ichthyoplankton in the pumped water, a phenomenon known as intake entrainment. Entrainment impact is calculated from such data as the estimated percentage of the population which passes near the intake that are in the entrainable size range and the percentage of those passing which are expected to be entrained.

Assumptions about fish larval transport affect the estimates of the two percentages profoundly. For example, the final environmental statement for the Indian Point Nuclear Generating Station Unit #2 on the lower Hudson River in New York (Atomic Energy Commission, 1972) contains an entrainment model (Figure 1) for larval striped bass (*Morone saxatilis*). The model hypothesized that the eggs and yolksac larvae drift from the freshwater zone of the estuary down to the brackish zone. By the time they reach the brackish zone, they are post-yolksac larvae, which then become concentrated in population density within the brackish zone because of an interaction between their behavior and the hydrodynamics of the brackish zone. Post-yolksac larvae of striped bass perform vertical die migration. The model postulated that when the larvae rise in the water column they are carried downstream by the upper freshwater layer, and that when they descend they are carried upstream

[1] The author wishes to acknowledge the support of the Power Authority in preparing this paper. Helpful comments were received from Peter Howe, biologist, of the Power Authority and Dr. Robert Kendall, technical editor of the American Fisheries Society.

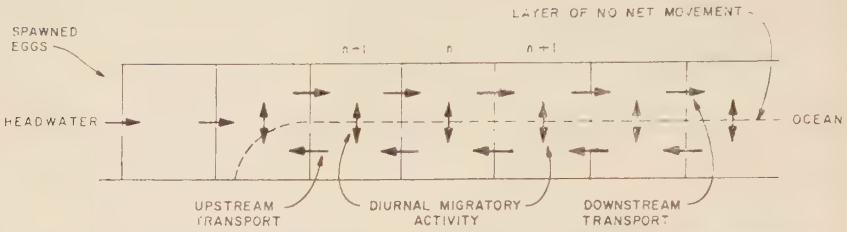

Figure 1. Diagram of estuarine transport model used to predict the downstream migration of larval striped bass in the Hudson River and the mortality resulting from entrainment. (From Atomic Energy Commission, 1972)

in the lower saline layer. They recirculate in an "endless belt" and thereby avoid being washed out to sea.

The same model postulated that the percentage of the larvae in the local estuarine sector that would be entrained by the plant would be equal to the percentage of the volume of water in the sector that would be entrained. Anomalies in larval transport, either along the estuary or at the intake, would render the impact predictions unrealistic. Data have been acquired which indicate that such anomalies do exist.

FIELD STUDY DATA

Several ichthyoplankton surveys were conducted along the Hudson estuary in the 1960's and 1970's. The data from these surveys indicate that the early life stages of the striped bass often maintain their longitudinal position in both the freshwater zone and the brackish zone of the estuary and do not simply drift *en masse* downstream. Table 1 presents records of the weekly abundance of larvae at various stations in 1966 as reported by Carlson and McCann (1969). Larval densities at the two stations in the brackish zone, Peekskill and Croton, did not show any distinct tendency to increase to a greater degree than those at the freshwater stations. Those stations which during the time of peak abundance showed high densities continued to show high densities, compared with those at the other stations, nearly to the end of the larval season.

In 1973, survey cruises of the Hudson estuary were made at weekly intervals from April 29 through August, and samples of the ichthyoplankton were taken in the various sectors indicated in Figure 2. The sectors recognized, in ascending order up the river, were: Yonkers, Tappan Zee, Croton-Haverstraw, Indian Point, West Point, Cornwall, Poughkeepsie, Hyde Park, Kingston, Saugerties, Catskill and Albany. In each case, the sector designated by a locality represented the area between the mid-points of the distances to the adjacent localities on either side. In 1974, similar observations were made, at somewhat shorter intervals, from late April through August. For each cruise, the average

TABLE 1. WEEKLY ABUNDANCE OF STRIPED BASS LARVAE AT VARIOUS STATIONS IN THE HUDSON RIVER ESTUARY IN 1966*

	Station§							
Week	Coxsackie (200)	Saugerties (168)	Kingston (146)	Hyde Park (131)	Marlboro (110)	Cornwall (90)	Peekskill (73)	Croton (57)
April 17-23	..	..	..	..	..	..	..	..
24-30	..	..	..	..	..	..	..	..
May 1-7	..	..	..	..	..	..	..	..
8-14	..	..	..	..	..	..	..	..
15-21	..	..	..	..	..	0.02	..	..
22-28	..	..	..	..	0.25	0.01	..	..
May 29-June 4	..	..	0.17	1.31	0.18	0.05	0.11	..
June 5-11	..	..	0.62	4.07	1.87	0.46	0.80	0.14
12-18	..	0.23	0.40	1.45	0.92	4.38	2.36	0.13
19-25	..	0.11	0.64	0.86	0.89	1.81	0.89	0.17
June 26-July 2	..	..	0.07	0.20	0.04	0.56	0.75	0.12
July 3-9	..	..	0.15	0.66	0.16	0.65	0.38	0.20
10-16	..	..	0.07	0.14	0.17	0.39	..	..
17-23	†	†	†	†	..	†	†	†
Average	0.00	0.17	0.30	1.24	0.56	0.87	0.88	0.15

* From Carlson and McCann (1969); data represent number per 1,000 cubic feet (or 28.3 cubic meters), blanks indicate samples were taken but no striped bass larvae were recorded.

§ Figures in parentheses are river kilometers from mouth.

† Not sampled.

density was calculated for yolksac larvae and post-yolksac larvae of striped bass, white perch (*Morone americana*) and American shad (*Alosa sapidissima*) as shown in Table 2. The dates included in the table represent the periods each year during which larvae were present in significant numbers.

Using the values for striped bass in 1974 (from Table 2) together with similar values for each sector (Texas Instruments, 1975), both in terms of larvae per 1,000 cubic meters, the relative density for each sector was calculated from the formula

$$\text{relative density} = \frac{\text{sector density}}{\text{average cruise density}}$$

The results are plotted in Figure 2 for each cruise from May 13 to July 15. They indicate that, even in July when most young striped bass had moved to the shallows, the freshwater zone retained relatively high densities of post-yolksac larvae in the channel. Indeed, a density peak in the Kingston sector persisted from June 12 to July 15.

Relative densities in 1973 were calculated from the same formula using values for striped bass larvae from Table 2 and sector densities

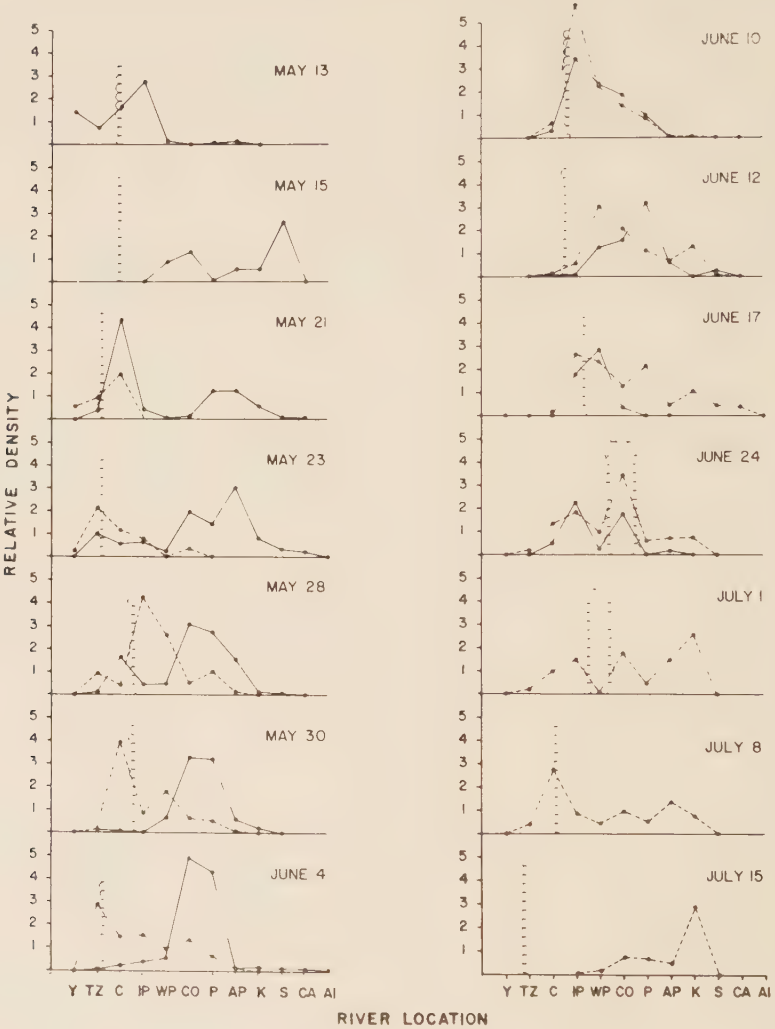

Figure 2. Relative density of yolksac (solid line) and post-yolksac (dash line) larval striped bass in the various sectors in the Hudson estuary in 1974. Vertical spirals indicate position of the salt front during sampling. Sector abbreviations are as follows: Y—Yonkers; TZ—Tappan Zee; C—Croton-Haverstraw; IP—Indian Point; WP—West Point; CO—Cornwall; P—Poughkeepsie; HP—Hyde Park; K—Kingston; S—Saugerties; CA—Catskill; Al—Albany.

from Texas Instruments (1976). The results are plotted in Figure 3 for each cruise from May 6 to July 22. They indicate a similar stability in the distribution of larval density to that observed in 1974. The brackish sectors did not show ever increasing concentrations of larvae compared with those in the freshwater sectors, and variations in the position of

TABLE 2. AVERAGE DENSITIES OF YOLKSAC LARVAE AND POST-YOLKSAC LARVAE, BY SPECIES, FOR EACH CRUISE IN 1973 AND 1974*

Date	Yolksac larvae			Post-yolksac larvae		
	Striped bass	White perch	American shad	Striped bass	White perch	American shad
			1973			
April 29	..	..	..	..	..	63.50
May 6	3.11	..	6.67	..	..	12.38
13	64.50	4.91	21.00	..	5.00	23.38
20	23.33	9.17	5.67	11.00	6.00	18.67
27	2.88	2.43	7.40	2.00	1.00	4.88
June 3	177.18	10.33	6.50	3.50	11.14	26.89
10	162.57	16.17	..	147.86	10.00	20.70
17	..	..	..	23.67	25.62	19.50
24	..	..	..	75.27	35.73	..
July 1	..	..	..	11.88	9.62	..
8	..	..	..	5.62	2.00	..
15	..	..	..	2.67	2.57	..
22	..	..	..	3.14	..	..
			1974			
May 13	1.53	1.57	xxx	..	0.56	xxx
15	2.11	10.04	xxx	..	3.40	xxx
21	36.75	51.76	xxx	1.38	11.04	xxx
23	14.60	13.95	xxx	1.35	14.49	xxx
28	78.37	32.88	xxx	14.92	53.58	xxx
30	63.27	9.73	xxx	79.77	30.89	xxx
June 4	29.07	10.55	xxx	42.04	63.68	xxx
10	61.98	10.64	xxx	96.14	173.98	xxx
12	11.15	21.90	xxx	162.56	189.67	xxx
17	6.97	1.63	xxx	142.61	133.87	xxx
24	1.17	2.84	xxx	64.12	85.40	xxx
July 1	..	1.29	xxx	14.02	16.10	xxx
8	..	..	xxx	7.33	13.79	xxx
15	..	..	xxx	9.01	4.69	xxx
22	..	..	xxx	..	4.98	xxx

* Data represent number per 1,000 cubic meters; blanks indicate samples were taken but no larvae of species were recorded. Only samples containing larvae were included in the averaging. For example, if only two stations on a cruise yielded samples with striped bass larvae, then the average density of such larvae for that cruise was the average of the samples from those two stations.

peak concentrations appeared unrelated to variations in the position of the salt front.

Figures 4 and 5 present the patterns of relative density for white perch larvae during 1973 and 1974, respectively, using values derived in the same manner as those for striped bass. Peaks in concentrations of yolksac larvae were usually either accompanied or followed shortly by similarly located peaks for post-yolksac larvae, an indication of positional stability, e.g., at Saugerties from May 13 to June 17 in 1973 and at Kingston from May 13 to July 1 in 1974. The distribution of white perch from late May through early June was generally similar to that of striped bass during both years.

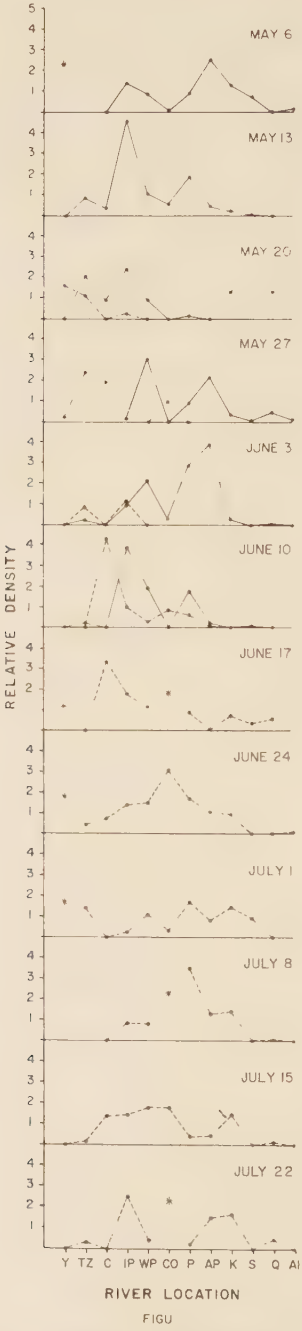

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Figure 3. Relative density of yolksac (sold line) and post-yolksac (dash line) larval striped bass in the various sectors in the Hudson estuary in 1973. (See Figure 2 for sector abbreviations)

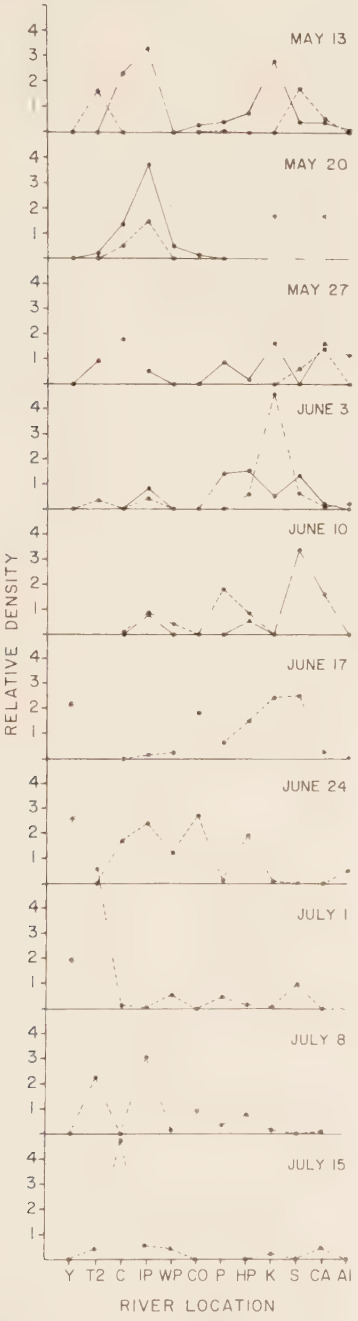

Figure 4. Relative density of yolksac (solid line) and post-yolksac (dash line) larval white perch in the various sectors in the Hudson estuary in 1973. (See Figure 2 for sector abbreviations)

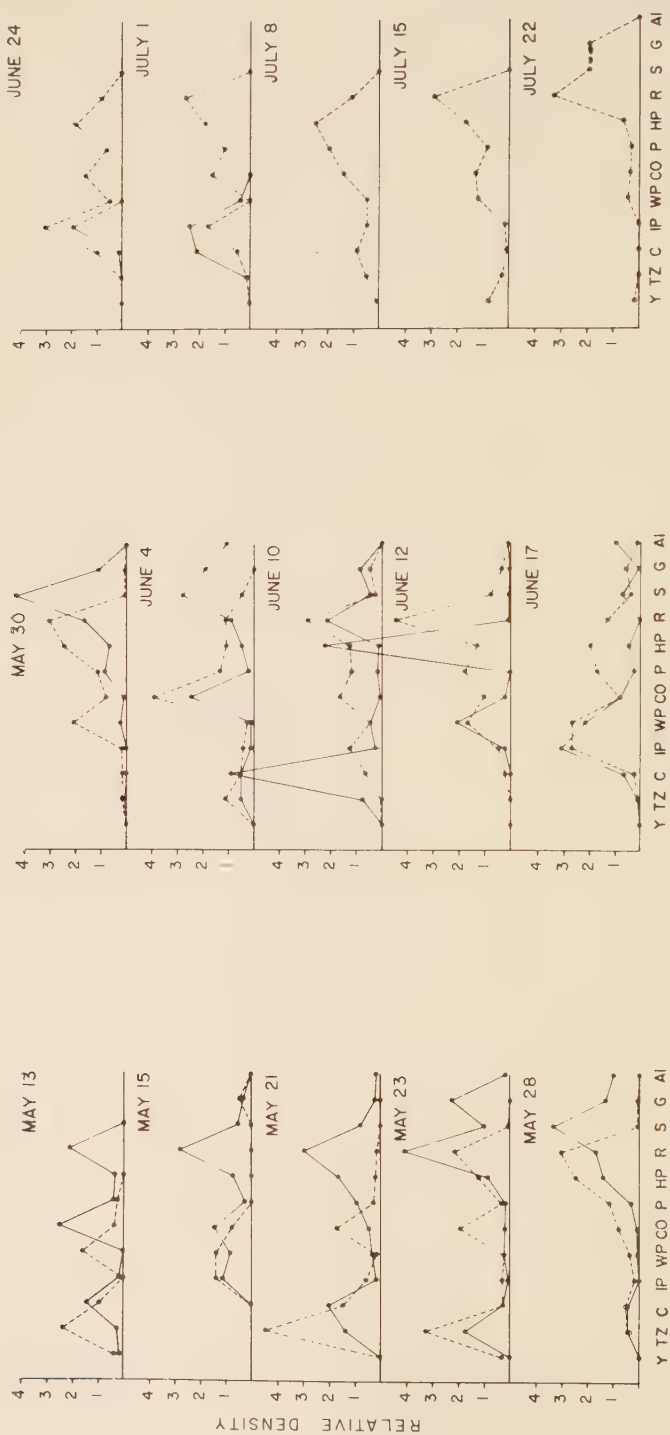

Figure 5. Relative density of yolksac (solid line) and post-yolksac (dash line) larval white perch in the various sectors in the Hudson estuary in 1974. (See Figure 2 for sector abbreviations)

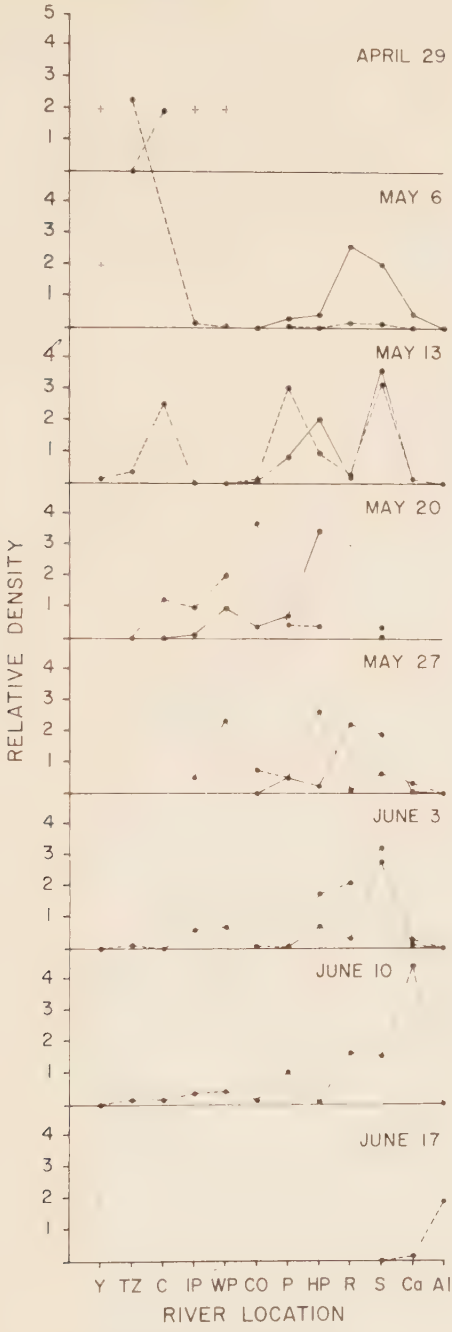

Figure 6. Relative density of yolksac (solid line) and post-yolksac (dash line) larval American shad in the various sectors in the Hudson estuary in 1973. (See Figure 2 for sector abbreviations)

The relative densities of American shad larvae in 1973, derived in the same manner as described for striped bass, are shown in Figure 6, for comparison with those of the two serranid species. The general pattern of the distribution from late May to mid-June was similar to that of white perch, with elevated densities in the river reach from Poughkeepsie to Catskill in early June. Although the larvae of the American shad are considered truly pelagic, their transport characteristics appear similar to those of white perch larvae. The difference in spawning distribution between striped bass and shad may govern the difference in the larval distribution.

GENERATING PLANT DATA

If fish larvae are simply transported along with the water mass surrounding them, the larval densities in the entrained water should be equal to those in the ambient water. Data from a generating plant on Lake Michigan and one on Lake Ontario show that larval densities were lower in the intake water at these plants than they were in the nearby ambient lake water. Figures 7 and 8 present sampling results for larval

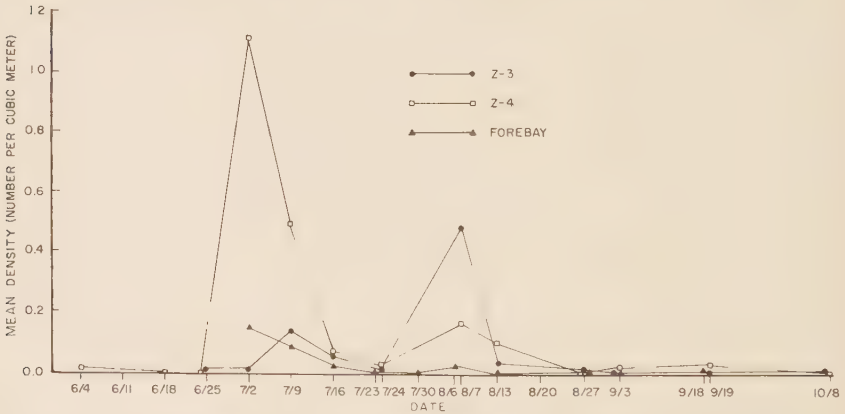

Figure 7. Mean density of larval alewives near the plant intake, i.e., 1,000 feet to the north (Z-3) and 1,000 feet to the south (Z-4), and in the forebay at the Zion Nuclear Generating Plant of the Commonwealth Edison Company. (From Cima et al., 1976)

alewives (*Alosa pseudoharengus*) and rainbow smelt (*Osmerus mordax*), respectively, at the Zion Nuclear Generating Plant of the Commonwealth Edison Company as reported by Cima et al. (1975). On nearly all sampling dates, densities were lower in the forebay than in the lake. A similar phenomenon was observed at the FitzPatrick Nuclear Generating Plant on Lake Ontario (Howe, personal communication, 1976).[2]

[2] Peter H. Howe, biologist of the Power Authority of the State of New York in charge of studies at the FitzPatrick plant; data were acquired by Lawler, Matusky and Skelly, Engineers.

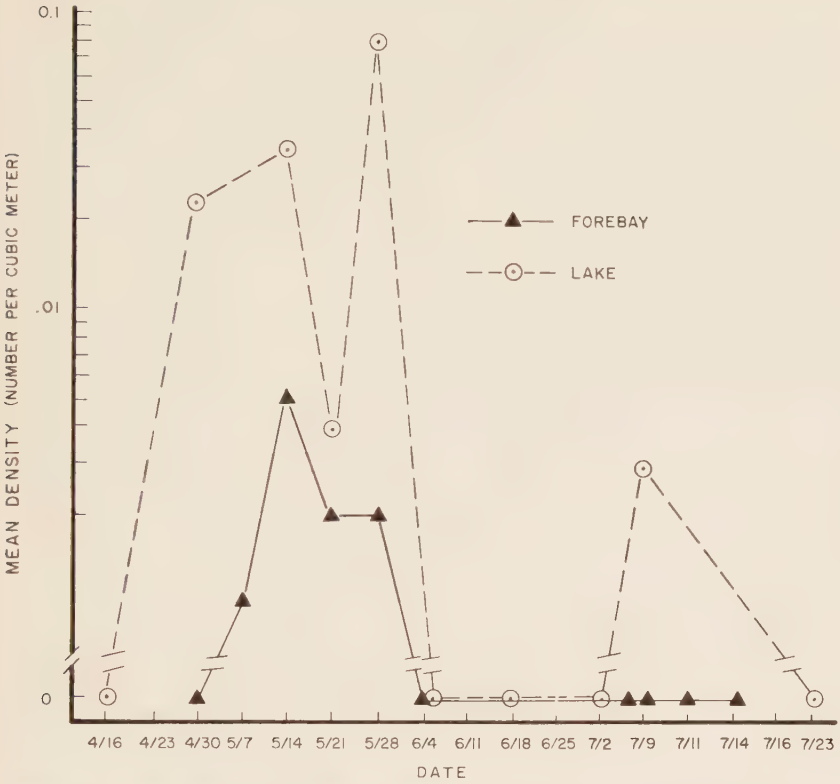

Figure 8. Mean density of larval rainbow smelt near the plant intake and in the forebay at the Zion Nuclear Generating Plant of the Commonwealth Edison Company. (From Cima et al., 1976)

DISCUSSION

From both the field surveys in the Hudson estuary and the data from the Great Lakes generating plants, it appears that the transport of fish larvae cannot be represented by the simple model assumption that their movement is identical with that of the ambient water mass. The aggregations of larvae in the Hudson estuary appear to move under particular hydrodynamic conditions, otherwise they tend to remain stationary in the deep, narrow bottlenecks of the river. Even some slight upriver shift of density peaks can be seen in the data, although, of course, the net movement was downstream. The California Resources Agency (Turner, 1972) also found significant differences in transport characteristics and positional stability for striped bass larvae between a tidal waterbody and a unidirectional river. Simply adding fish larvae into the pattern of estuarine circulation does not yield a realistic estimate of the proportion of the population which passes an intake transect. Yet this sort of model

is still being applied in environmental assessment, e.g., that contained in Nuclear Regulatory Commission (1975). The maintenance of longitudinal position by larval aggregations in both the freshwater and brackish zones of an estuary casts doubt on the results of such model design. Transport in other types of waterbodies, such as lakes and sounds, also needs to be reviewed for this anomaly.

The generating plant data indicate that simply applying the volume ratio of the entrained water to the ambient water mass will not yield a true ratio of the larvae entrained to the local population. These numbers must be obtained by a sampling program because the natural and plant-induced flows at different plants will affect ichthyoplankton movement in different ways. Most empirical data would probably show that entrainment estimates based on a water-volume ratio are highly conservative. In cases of plants not yet in operation, where water-volume ratio is the only means of predicting impact because empirical data cannot be acquired, such predictions should be viewed with caution because of their limitations.

A pilot program of simple observations of larval responses to different hydrodynamic conditions would be valuable in understanding the seemingly erratic transport of fish larvae. A very large fish flume to which an irregularly contoured bottom could be fitted would facilitate such study. It would be desirable to observe both demersal and pelagic larvae, with the goal of building a qualitative physical description of larval transport. In the midst of a flurry of highly refined, highly sophisticated mathematical model projection, the basic element of how fish larvae are influenced by the ambient water currents is still largely unknown.

Estimates of entrainment are both environmentally and economically important. Overestimates can lead to projections of rapidly declining populations such as that of Goodyear (1974) for striped bass. Overestimates can also lead to legal decisions requiring drastic plant changes such as the addition of cooling towers. Large industrial installations are expensive to change. A change in the intake structure only may cost tens of millions of dollars. A cooling tower, including operation, may cost 80 to 100 million dollars. Such costs must be reflected in what the consumer pays for the product involved.

CONCLUSIONS

Data from both field surveys and generating plants indicate that fish larvae do not move in a simple relationship with the surrounding water mass. Larval aggregations may be stable in geographic position for relatively long periods, i.e., up to several weeks. Also, fish larvae are not always entrained in densities comparable to ambient densities.

Transport through the natural waterbody and that at the plant intake

determine the proportion of the total population that gets into the plant. Determination, by both field and laboratory observation, of the conditions which foster larval transport and of its various velocities is of great importance both environmentally and economically. Further attempts to design models of larval transport may be a waste of time and money without a qualitative physical understanding of the process. Application of present transport models may lead to expensive and poorly based decisions.

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SOME CHARACTERISTICS OF NEW YORK HUNTERS[1]

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ABSTRACT

A random sample of persons who bought 1970-71 licenses to hunt in New York State were surveyed by mail questionnarie to determine some of their characteristics. Those who responded were above the average for the total United States population in educational achievement, and the majority had hunted from six to 10 years. They preferred to hunt big game, and a large proportion were also fishermen. They supported the Department of Environmental Conservation's hunter safety training program and strongly favored conservation education in schools.

In New York, as in all of North America, hunters are unique compared with their counterparts in most other countries. Here, hunters come from all walks of life, whereas in other countries they are characteristically members of the upper class (Gottschalk, 1972). In New York, 39 per cent of the hunters are white-collar workers, 42 per cent are blue-collar workers and 12 per cent are engaged in forestry or farming (Bevins et al., 1968). Most of them (70-72 per cent) spent the early part of their lives in rural areas (Bevins et al., 1968; Bond and Whittaker, 1971; Palmer, 1967). There they became interested in recreational hunting activities when they were "in touch with the land". Unlike 30 years ago, 73.5 per cent of the United States' population now live in metropolitan or suburban environments (Reader's Digest Almanac, 1971) and are becoming "out of touch with the land". This trend toward urbanization is changing the characteristics of sportsmen in New York.

The study reported here was conducted to define some of the present characteristics of hunters in New York. In 1972, a questionnaire was sent to persons who bought a 1970-71 license to hunt (big game, small game or combination hunting and fishing). A random sample of 405 licensees was selected for the survey from the license stubs retained by the issuing clerks, the number for each county being pro-rated according to the number of licenses sold in that county. The questionnaire, a multiple-choice type, was sent out with an explanatory covering letter and a return envelope. Of the 405 sent, 36 were undeliverable and 199 drew no response. A total of 170 were returned, including five from elderly people who felt that, since they no longer hunted, their information would not be helpful. Replies were received from residents of 51 of the 62

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[1]Derived from an M.S. thesis submitted to the Graduate School of the College of Environmental Science and Forestry at Syracuse University. The author wishes to thank Dr. David Hanselman for his help in writing the thesis and Donald Foley for his suggestions during the research project.

TABLE 1. DISTRIBUTION OF HUNTING LICENSEES SENT QUESTIONNAIRE AND OF THOSE WHO RESPONDED

County or out-of-state	Number sent questionnaire	Number responding
Albany	9	1
Allegany	4	2
Bronx	4	1
Broome	12	4
Cattaraugus	6	1
Cayuga	5	0
Chautauqua	8	5
Chemung	5	3
Chenango	6	3
Clinton	4	2
Columbia	3	0
Cortland	3	0
Delaware	4	3
Dutchess	8	2
Erie	34	13
Essex	3	1
Franklin	3	2
Fulton	2	0
Genesee	4	2
Greene	2	2
Hamilton	1	1
Herkimer	4	2
Jefferson	5	0
Kings	7	4
Lewis	2	1
Livingston	4	3
Madison	4	3
Monroe	26	7
Montgomery	3	1
Nassau	10	4
New York	2	1
Niagara	13	6
Oneida	11	5
Onondaga	18	4
Ontario	6	3
Orange	8	4
Orleans	3	1
Oswego	6	2
Otsego	4	3
Putnam	2	0
Queens	7	2
Rensselaer	6	4
Richmond	2	1
Rockland	4	2
St. Lawrence	6	2
Saratoga	5	2
Schenectady	6	0
Schoharie	2	0
Schuyler	2	1
Seneca	2	0
Steuben	9	3
Suffolk	15	6
Sullivan	3	1
Tioga	3	0
Tompkins	4	1
Ulster	8	6
Warren	3	1
Washington	3	1

Table 1. *(continued)*

County or out-of-state	Number sent questionnaire	Number responding
Wayne	6	1
Westchester	11	6
Wyoming	3	2
Yates	2	0
Out-of-state	25	13
Total	405	170

counties of the State, and 13 of 25 out-of-state residents responded. The distribution of the licensees selected and of the respondents is shown in Table 1. The data from the respondents were transferred to punch cards and analyzed by a computer at the College of Environmental Science and Forestry.

CHARACTERISTICS OF RESPONDENTS

Of the licensees who responded: 26 (15.8 per cent) were between 14 and 20 years of age; 126 (76.3 per cent) were between the ages of 21 and 59; and 13 (7.8 per cent) were age 60 or over. The average age was 37 years. Nine were female.

Only 7 per cent of those who filled out the questionnaire had no more than an eighth grade education, compared with 28.8 per cent for the United States' population as a whole in 1971 according to the Reader's Digest Almanac (1971). Of those in the present survey, 39 per cent had attended college for at least one year, compared with a national average of 20.5 per cent. Both sources of information indicated that 33 per cent had completed at least 12 years of school. It would seem that the hunters who furnished the data reported here were above average in education (Table 2).

The degree to which those who responded were currently hunting different types of game is shown in Table 3. Big game hunting was engaged in by the greatest proportion (85 per cent), followed by pheasant hunting (76 per cent). Bevins et al. (1968) and Klessig and Hale (1972) found that 84 per cent of the sportsmen they surveyed hunted deer. Also given in this table is the hunting preference of the respondents. The majority (54 per cent) preferred big game hunting. Although not included in the table, 24 per cent said they preferred bowhunting only.

The relative amount of hunting done by the respondents each year and their preference for duration of the hunting season are shown in Table 4. Few hunted more than a month, and few indicated that they wished more than a month of hunting although 49 per cent preferred a season of 11 days or more. The information regarding the preferred duration of season is admittedly very general because the question was not linked to any species or combination of species.

Table 2. Percentage of Respondents According to Number of Years They Had Attended School Compared With Data From Other Localities

Locality	Years of school attendance							
	8 or less	9	10	11	12	13	14	College or more (16+)
New York (present study)	7	5	6	9	33	10	11	18
Michigan (Palmer, 1967)	22.8	..	24.9	..	27.9	..	22.4	..
Nevada (Garrett, 1970)	4.11	8.13	24.19	..	37.9	..	11.63	9.85
Northeast* (Bevins et al., 1968)	16	..	25	..	37	..	13	9
Ohio (Peterle, 1967)	6	..	9	..	78	..	7	..
Pennsylvania (Sofranko et al., 1970)	17.2	..	69.1	..	..	..	6.4	7.3
Wisconsin (Klessig et al., 1972)	13	..	12	..	41	..	13	21
United States§ (Reader's Digest Almanac, 1971)	28.8	..	17.2	..	33.5	..	9.8	10.7

* Includes Maine, Massachusetts, New York, Pennsylvania, Vermont and West Virginia.

§ Average for 1971 for all persons 25 years or more of age, not just sportsmen.

Table 3. Percentage of Respondents Who Currently Hunted Different Types of Game Compared With Their Hunting Preference

Type of game	Current hunting	Hunting preference
Big game (deer and bear)	85	54
Pheasant	76	12
Waterfowl	55	10
Grouse and woodcock	69	7
Rabbits and hare	70	5
Varmints and predators	68	5
Raccoon	30	1
Unknown	..	6

Table 4. Percentage of Respondents According to Number of Days They Hunted Each Year and Their Preference For Duration of Season

Number of days	Annual hunting*	Preferred duration of season
0 - 5	4	16
6 - 10	12	29
11 - 15	8	21
16 - 20	15	14
21 - 25	8	6
26 - 30	14	2
31 - 35	§	0
36 - 40	§	0
41+	§	7
31 - 50	5	§
51+	3	§
No answer	31	5

Table 5 indicates the relative number of years the hunters surveyed had hunted, trapped or fished. The majority had hunted for six to 10 years, but most had trapped for not over five years. However, the data show that fishing is a much longer-term activity. It should be noted that in New York a person must be at least 14 years old to hunt small game and 16 years old to hunt big game[2], whereas one may fish at any age and no license is required of those under 16.

With respect to the origin of their interest in hunting, 47 per cent of the respondents stated that they had been motivated by a friend or relative, while 46 per cent said they were self-taught.

Concerning affiliation with sportsmen's organizations, 46 per cent of the respondents stated that they were not members of a local organization, while 20 per cent noted membership from 1 to 5 years, and 13 per cent from 6 to 10 years. Of the hunters surveyed, 27 per cent belonged to the National Rifle Association, and 10 per cent belonged to some other national group, e.g., the National Wildlife Federation, National Audubon

[2]In 1976 a junior archery license was instituted permitting residents 14 or 15 years old to hunt deer with bow and arrow.

TABLE 5. PERCENTAGE OF RESPONDENTS ACCORDING TO NUMBERS OF YEARS THEY HAD HUNTED, TRAPPED OR FISHED

Number of years	Hunted	Trapped	Fished
0 - 5	2	17	5
6 - 10	54	6	10
11 - 15	12	2	13
16 - 20	10	2	18
21 - 25	5	1	13
26 - 30	5	1	11
31 - 35	0	0	5
36 - 40	1	1	5
41+	4	1	8
No answer	7	69	12

Society, etc. But 62 per cent were not members of any national group in 1972. However, 45 per cent were members of some conservation group holding meetings, usually monthly, during the year.

A large proportion (86 per cent) of these hunters were also fishermen, and 64 per cent engaged in hiking and camping. Those who participated in nature study, bird watching and wildlife photography amount to 38 per cent.

ATTITUDES OF HUNTERS SURVEYED

Those who received the questionnaire were asked where they would go first for technical information on wildlife. Many of the respondents (18 per cent) felt they could answer "technical" questions on wildlife from their own knowledge. However, 40 per cent would go to a conservation officer (of the Department of Environmental Conservation), 15 per cent to a field biologist and 10 per cent to a library. The large proportion who would rely on a conservation officer indicates the need for these officers to be knowledgeable on such subjects.

Of the hunter surveyed, 85 per cent felt that the hunter safety training program sponsored by the Department could be improved, while only 10 per cent felt that the existing program was sufficient. It may be noted that, while emphasis originally was on firearms safety, bowhunting was added in 1960. Then, too, the program has been expanded to include hunting ethics and the hunter's image, landowner-sportsman relations and wildlife management. Also, on some of the State and Federal waterfowl management areas, e.g., Montezuma National Wildlife Refuge and Howland Island Wildlife Management Area, preference is now being given to waterfowl hunters who have passed a course in waterfowl identification.

Another question asked was "Would you support a duck stamp for New York State?" The majority of respondents (60 per cent) would support a duck stamp only if mandatory, but 14 per cent said they would voluntarily support such a stamp. Only 21 per cent were definitely opposed to a New York duck stamp. The remaining 5 per cent had no preference.

Table 6. Percentage of Respondents Favoring Different Degrees of Priority With Respect to Programs on Which License Funds* Are Spent

Program	Priority					Did not answer
	Very high	High	Medium	Low	Very low	
Stocking fish and game	61	15	9	2	7	6
Habitat improvement (fish and game)	52	20	5	5	8	9
Improving quality of human environment§	37	18	11	5	16	12
Conservation education in schools	34	21	19	8	10	9
Research on game species	29	25	19	10	4	13
Leasing hunting and fishing rights	22	20	19	7	21	12
Research on non-hunted species	14	10	29	14	18	14
Predator control (including bounties)	14	8	21	10	32	14

* Represents proceeds from sales of licenses to hunt, fish and trip and from fines for violation of Fish and Game Law.

§ Abatement of water pollution, noise and air pollution etc.

With respect to the use of revenue from license fees, the respondents indicated that habitat management and the stocking of fish and game should have the highest priority, but they felt that improving the quality of the human environment (abatement of water pollution, noise, air pollution etc.), conservation education in schools and research on game species were also important (Table 6). At the time of this survey, the reorganization of the Conservation Department into the Department of Environmental Conservation had been in effect only two years, and the consensus among the hunters surveyed was that this had made little difference except for possible improvement in the pollution control program.

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GENERAL NOTES

MAINTENANCE OF A TROUT FISHERY BY AERATION IN A EUTROPHIC LAKE[1]

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Lake Waccabuc is located in Westchester County (N.Y.) some 80 kilometers north of New York City at an elevation of 180 meters above sea level. It has a surface area of 53 hectares (124 acres) and a maximum depth of 13.5 meters. It is characterized by low levels of dissolved oxygen and has become increasingly eutrophic in recent years. Its fish population has consisted of warmwater species. Generally, an unaerated eutrophic lake where summer temperatures in the epilimnion approach 27° C. cannot support a salmonid fishery because the meta- and hypolimnion become anoxic during summer stratification (pre-aeration conditions in Lake Waccabuc).

During the summer of 1973, a Limno (Atlas Copco, Inc.) hypolimnetic aeration system was installed in the lake. This system maintained summer oxygen levels between 3.5 and 7.0 milligrams per liter in the hypolimnion at depths of 8 to 14 meters through 1975 and did not alter the summer thermal stratification. It did not oxygenate the generally anoxic metalimnion between 6 and 8 meters. The performance of the system and its effects on nutrients were described by Fast et al. (1973) and Garrell et al. (1977).

In August 1973, two months after installation of the aeration system, Lake Waccabuc was stocked with 2,100 salmonids 20 to 30 centimeters long: 1,500 rainbow trout (*Salmo gairdneri*), 300 brown trout (*Salmo trutta*) and 300 brook trout (*Salvelinus fontinalis*). During the summer of 1975, project personnel took specimens by angling for measurement and analysis of stomach contents. A creel census taken by the Three Lakes Council, a local citizen's group, provided additional information about fish sizes and about where fish were caught in relation to the location of the two aerators. Creel census participants were also asked to preserve stomach contents for project analysis whenever possible.

A total of 30 rainbow trout were taken by project personnel and creet census participants between July 4 and August 31. The distribution of these fish, both as to location and depth where caught, is shown in Figure 1. With one exception, they were taken from the oxygenated hypolimnion in water ranging from 9 to 14 meters deep. These fish showed excellent growth during their 24-month residence in the lake, ranging from 36 to 45 centimeters in length and from 750 to 1,010 grams in weight. No brown trout or brook trout were taken.

Only nine trout stomachs were obtained for examination. Unfortunately, cooperating fishermen tended to discard the entrails without thinking, although they usually measured the trout they caught. All of these fish apparently had fed principally in the hypolimnion as indicated by their stomach contents (Table 1). This agrees with the findings of Fast (1973) and Overholtz (1975). However, for three specimens there was evidence of feeding in the epilimnion.

The data indicate that the rainbow trout made occasional forays through the anoxic metalimnion into the fertile epilimnion, but that they did not most of their feeding in the hypolimnion. The fish apparently spent most of the summer in the

[1]This study was supported under contract No. 2-4-XXX-454 from the Union Carbide Corporation.

Figure 1. Map of Lake Waccabuc showing position of the air lines and aerators, together with the locations where the rainbow trout examined were taken. Numerals denote number of specimens at each location.

Table 1. Sex, Size and Foods Represented in Stomach Contents of Nine Rainbow Trout Taken in Waccabuc Lake in 1975

Date taken	Sex	Length*	Girth*	Weight§	Food							
					Chaoboridae (phantom midges)	Culicidae (mosquitoes)	Chironomidae (midges)	Caldocera (water fleas)	Odonata (dragon flies)	Ephemeroptera (mayflies)	Coleoptera (beetles)	Miscellaneous fish material
July 4	..	38.2	25.4	790	x							
9	..	35.6	..	..	x							x x
29	Male	36.8	20.4	..	x		x	x	x			
29	Female	35.6	..	..	x		x	x				
?	Female	39.4	21.6	740	x		x	x				x
August 1	Female	39.4	22.8	740	x		x	x				
17	Female	43.1	20.4	910	x	x	x			x	x	x
20	..	43.5	..	910	x	x	x					
20	..	44.5	..	1,010	x	x	x					

* In centimeters.

§ In grams.

oxygenated hypolimnion near the aerators or downlake from the eastern aerator and grew considerably in the aerated environment. A resurgence in the numbers of white perch (*Morone americana*) since summer aeration began, as well as a return of large yellow perch (*Perca flavescens*) schools with an absence of summer fish-kills, indicated that hypolimnetic aeration can possibly be beneficial to species other than salmonids. Therefore, it is concluded that hypolimnetic aeration can maintain a cold-water fishery that would otherwise not survive in a eutrophic lake and can improve the environment for existing species.

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SABELLARIA VULGARIS AS A FOULING ORGANISM OF AMERICAN LOBSTER[1]

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On April 29, 1976, 692 American lobsters (*Homarus americanus*) were taken aboard a commercial lobster boat fishing in Long Island Sound off Eaton's Neck, N.Y. Of these lobsters, 167 were encrusted with worm tubes which were found to hold live *Sabellaria vulgaris*, a marine annelid belonging to the family Serpulidae. This appears to be the first confirmed record of *S. vulgaris* as a fouling organism on lobsters. Herrick (1895) referred to a tube-building annelid as among the fouling organisms of the lobster, but he did not identify it. Dexter (1955) recorded a serpulid, tube-building annelid, but he did not identify it either.

Gosner (1971) described the range of *S. vulgaris* as the Virginia Province (Cape Cod to Cape Hatteras), from the littoral zone to 8 meters in depth. Miner (1950) described it as "very common from Virginia Sound to New Jersey." It has been found as a fouling organism of the horseshoe crab (*Limulus polyphemus*), scallops (in Florida, species not given) and American oyster (*Crassostrea virginica*) according to Curtis (1973), Eckelbarger (1975) and Maurer and Watling (1973). The lobsters collected in the present instance were in water about 30 meters deep, indicating either that they had acquired *S. vulgaris* in shallower water or that the organism exceeds the depth range reported by Gosner (1971).

[1]Contribution No. 78-1 of the Division of Marine Resources. The author thanks David J. Fallon of the New York State Department of Environmental Conservation for confirming the identification of *Sabellaria vulgaris*.

Of the lobsters with *S. vulgaris*, 96 per cent were ovigerous females. Fewer organisms were found on males and non-ovigerous females. This was probably a result of the molt cycle of the lobster in Long Island Sound. It has been shown that lobsters in the Sound undergo molts during the spring and fall (Lund et al., 1973) and perhaps during the winter (Briggs and Mushacke, unpubl.). However, mature females that extrude their eggs in late summer or early fall retain their shells and are not involved in the fall or winter molts. Hence the greater incidence of *S. vulgaris* on the ovigerous females is explained by their less frequent molting.

Temperatures in Long Island Sound in late summer and early fall average between 16° and 24° C. (Galstoff, 1964, Figure 368). Eckelbarger (1975) reported that *S. vulgaris* readily spawned (in the laboratory) at 21° to 23° C. Curtis (1973) found that it settled at a temperature of 13° C. in Delaware Bay in late May and early June. He also stated that continuous spawning occurred from June through October. Given the temperature ranges in Long Island Sound and the temperatures favorable for spawning of *S. vulgaris*, it is probable that the majority of the lobsters encrusted with this organism acquired it in summer or early fall.

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ADDENDUM

Since this note was written, the author has learned that the presence of *Sabellaria vulgaris* as a fouling organism on American lobsters in Long Island Sound was also observed by Smith sometime during the spring or early summer of 1976 (Eric M. Smith. 1977. Long Island Sound Lobster Management. Nat'l. Marine Fish. Serv., Comm. Fish. Res. and Dev. Act, Completion Rept. for Conn. Project 3-253-R-1).

CUBERA SNAPPER FROM NEW YORK WATERS[1]

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On August 5, 1975, a large snapper was taken from a trap net in 18 feet (5.5 meters) of water in Fort Pond Bay at Montauk (N.Y.) and brought to the attention of the author by the net operator, James Lester, who made it available for examination. At that time the fish was examined by several biologists and identified as a cubera snapper (*Lutjanus cyanopterus*), after which it was frozen and subsequently transported to the American Museum of Natural History where it was added to their collection under Mr. Lester's name. Dr. C. Levitt Smith, Chairman of the Ichthyology Department of the Museum, confirmed the identification. Identification of this specimen as a cubera snapper makes it a positive record for the species in New York waters and supports the probable record reported by Schaefer (1973). It also represents a northward extension in its range of approximately 45 miles (73 kilometers) from where Schaefer's specimen was taken.

Cubera snapper (*Lutjanus cyanopterus*) taken near Montauk (N.Y.) August 5, 1975.

Morphological observations were recorded as follows: weight, 31¼ pounds (14.2 kilograms); total length, 36¾ inches (940 millimeters); dorsal fin, rays X-14; anal fin, rounded, rays III-8; pectoral fins, falcate, rays 15; pelvic fins, rays I-5; caudal fin, slightly lunate with lobes not much produced; vomerine tooth patch /\ -shaped; canine teeth, two very strong in upper jaw, seven moderate in lower jaw; gill rakers, six developed on lower limb of first arch; cheek scales, 10 rows. The body color was generally reddish with bluish-gray overtones dorsally, shading to pinkish-gray ventrally. All fins were pale rose or pink, becoming dusky toward the tips.

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[1]Contribution No. 78-4 of the Division of Marine Resources. The author wishes to acknowledge the assistance of Clarence Hickey of the U.S. Nuclear Regulatory Commission in the early identification of this cubera snapper.

The data conform well to the descriptions of the cubera snapper as given by Jordan and Evermann (1898), Meek and Hilderbrand (1925), Rivas (1949), Moe (1966), Anderson (1967), Böhlke and Chaplin (1968), Schwartz (1972) and Schaefer (1973). The specimen's size and weight alone would eliminate other species, except for the dog snapper (*L. jocu*), which has been reported to reach 100 pounds (45.3 kilograms), though few exceed a weight of 20 pounds (9.1 kilograms) according to Böhlke and Chaplin (1968). However, there is little likelihood of confusing the dog snapper with the cubera snapper after morphological examination.

As a further point of interest, it may be noted that on October 26, 1975 a local newspaper, The Long Island Press, carried a report of a large snapper weighing 72 pounds (32.7 kilograms) and measuring 34 inches (865 millimeters) in length that was captured by trawl in the Atlantic Ocean off Sea Isle City, New Jersey. The account called the fish a cubera snapper, which it may well have been considering the data given.

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FIRST RECORD OF THE SERGEANT MAJOR FROM NEW YORK WATERS[1]

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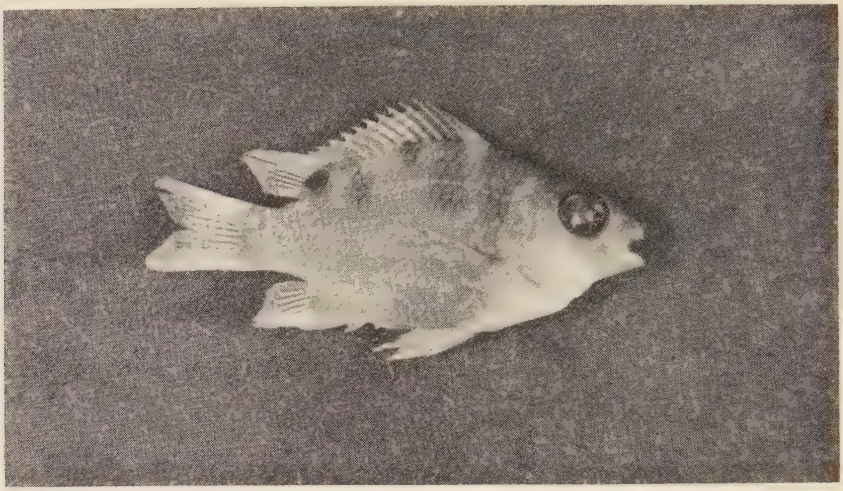
David J. Fallon — Senior Aquatic Biologist (Marine), New York State Department of Environmental Conservation

On September 24, 1974, a sergeant major (*Abudefduf saxatilis*) 32 millimeters in fork length was collected by dip net from a tidal pool on the western shore of Shinnecock Inlet on the southern shore of Long Island (N.Y.) The water temperature was approximately 20° C. So far as the authors have been able to

[1]Contribution No. 78-3 of the Division of Marine Resources.



First recorded sergeant major (*Abudefduf saxatilis*) from New York waters, taken in Shinnecock Inlet September 24, 1974 (32 millimeters in fork length).

learn, after an extensive review of the literature, this is the first record of the species from New York waters.

Breder (1948) noted that the sergeant major is primarily tropical in distribution, rarely straggling to Rhode Island. Böhlke and Chaplin (1968) described the range of the species as "warm water around the world; in the west Atlantic from New England and Bermuda to Uruguay, including the Gulf of Mexico". The only prior records from the Northeast are from Newport, Rhode Island (Nichols and Breder, 1926; Gordon, 1960) and along the New Jersey coast (Aaron, 1975; Milstein and Thomas, 1976).

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OCCURRENCE OF LARVAL INSHORE LIZARDFISH IN THE HUDSON RIVER ESTUARY[1]

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Theodore J. Chambers Senior Technician
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The range of larvae of the inshore lizardfish (*Synodus foetens*) can be extended to include the Hudson River estuary on the basis of four specimens collected in 1-square-meter plankton tows in the vicinity of Yonkers, N.Y. (Figure 1). Two

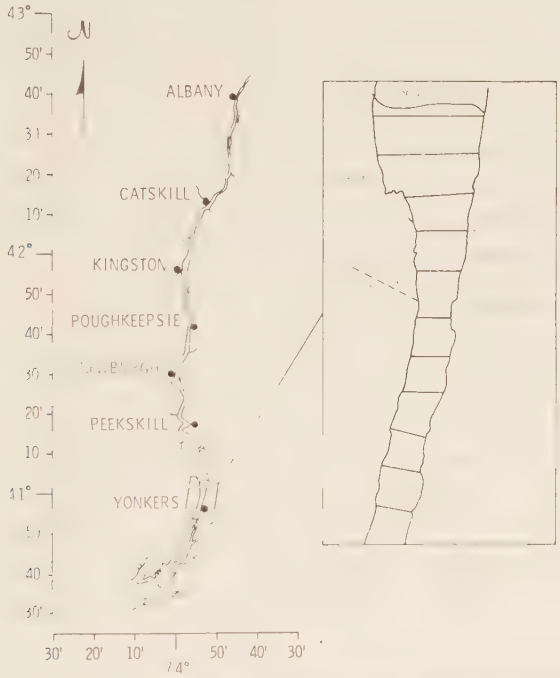

Figure 1. Map of Hudson River estuary showing area where larval inshore lizardfish were collected.

[1]The research was supported by the Consolidated Edison Company of New York, Inc., Contract 4-05051 awarded to Texas Instruments, Inc. The authors wish to thank William L. Dovel of Boyce Thompson Institute and Dr. Johnson C. S. Wang of Ecological Analysts, Inc. for reviewing the identifications, as well as Karen A. Kachura of Texas Instruments and M. E. Foddrill of Ecological Analysts for preparing the illustrations of the protopterygiolarva and pterygiolarva, respectively.

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Table 1. Data Pertaining to the Collection of Larval Lizardfish in the Hudson River Estuary in 1974

Data collected	River mile*	River depth (meters)	Sample depth (meters)	Temperature (° C.)	Salinity (ppt)
July 11	19	7.6	7.6	23.8	3.3
July 11	17	6.7	6.7	23.5	3.3
July 17	26	5.2	5.2	24.1	5.9
July 17	21	12.2	4.9	23.1	11.5

* Statute miles above Battery.

were collected on each of the nights of July 11 and July 17 in 1974 (Table 1).[4] Three of the specimens measured 20.7 to 25.9 millimeters in standard length, while the fourth was 14.4 millimeters long. Based on dorsal and pelvic fin development, the three largest specimens were in the pterygiolarval phase, while the other was in the late protopterygiolarval phase, according to the terminology of Balon (1975). The two phases are illustrated in Figure 2.

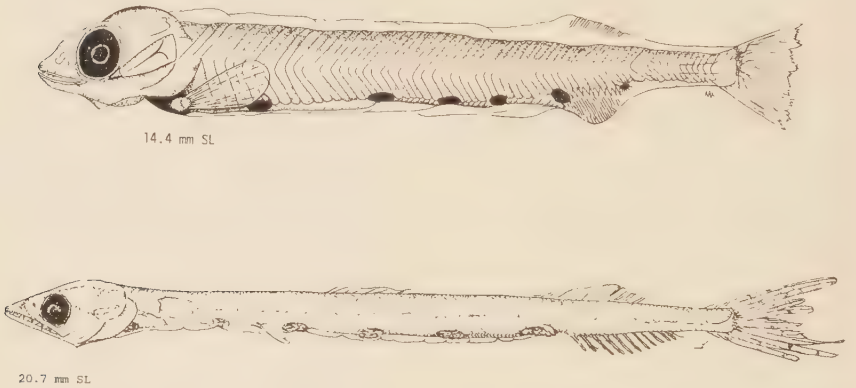

Figure 2. Late protopterygiolarval (above) and pterygiolarval (below) phases of the inshore lizardfish.

The larvae were identified by characteristics described by Gibbs (1959) and Mansueti and Hardy (1967). The distinct pigmentation pattern of larval inshore lizardfish was evident on all specimens, including six large ventrolateral peritoneal melanophores extending from the isthmus to the vent, as well as smaller chromatophores on the caudal peduncle and at the posterior insertion of the anal fin.

Inshore lizardfish have previously been reported from Long Island Sound by Greeley (1937) and Alperin and Schaefer (1965); however, these authors indicated that the specimens they saw had completed larval metamorphosis. Larvae have been recorded from the offshore waters of Virginia (Mansueti and Hardy, 1967) southward to the western coast of Florida (Breder, 1944) and in the Gulf of Mexico (Gibbs, 1959). Although their range extends as far north as Massachusetts (Hildebrand and Schroeder, 1928), inshore lizardfish are uncommon north of the Carolinas (Thompson et al., 1971).

[4] The specimens are presently in the Consolidated Edison Ichthyoplankton Longitudinal River Survey Reference Collection: Nos. 10-1269, 10-1272, 20-0932 and 20-0951.

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OCCURRENCE OF TRICHOMONIASIS ON LONG ISLAND

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Trichomoniasis is a protozoan disease which has been reported in a variety of doves and pigeons, as well as hawks and owls. Despite this variety of species, the domestic pigeon (*Columba livia*) is considered to be the primary host (Kocan and Herman, 1971).

Between May and September in 1976, eight confirmed cases of trichomoniasis from localities on Long Island (N.Y.), involving seven mourning doves (*Zenaidura macroura*) and one sparrow hawk (*Falco sparverius*) were encountered by the author (Table 1). Another dove was reported from Dix Hills on June 14, but

TABLE 1. CASES OF TRICHOMONIASIS IN BIRDS FROM LONG ISLAND EXAMINED IN 1976

Species and date	Locality	Pathology	Remarks
Mourning dove			
May 7	Great Neck	caseous necrotic mass in crop	
May 15	Huntington	necrotic lesions in crop and oral cavity; glottis partly occluded	
June 15	Dix Hills	caseous necrotic mass in esophagus and crop	bird feeder being maintained through summer
June 15	Dix Hills	caseous necrotic mass in esophagus and crop	bird feeder being maintained through summer
August 12	Westbury	caseous necrotic mass in crop	
August 26	Eaton's Neck	caseous necrotic mass in pharynx and cranial esophagus; pneumonia in left lung	bird feeder being maintained through summer
September 1	Eaton's Neck	caseous necrotic mass in pharynx; gout	bird feeder being maintained through summer
Sparrow hawk			
August 5	South shore of Long Island	necrotic stomatitis with sublingual caseous mass	found ill in spring; kept in captivity and seemed to recover, only to become ill again a week before death

it was not submitted for necropsy. These were the first encountered since the author began examining Long Island wildlife for disease in 1972. That none was seen prior to 1976 may have been due merely to the small number of doves that were examined in a given year, or it may indicate a recent increase in the mourning dove population and a consequent increase in the prevalence of this disease.

The specimens from Dix Hills and those from Eaton's Neck came from premises where bird feeding had been continued into the previous spring. Kocan (1969) reported that transmission of the causative organism, *Trichomonis gallinae*, could occur via contaminated feed or water. Saliva containing trichomonads, from domestic pigeons and doves, could contaminate backyard feeding areas, so that when mourning doves congregate there infection of susceptible individuals could result. This is another reason why it is advisable to cease feeding wild birds in the spring.

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